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CDM FEDERAL PROGRAMS CORPORATION
a subsidiary of Camp Dresser & McKee Inc.

February 8, 1994

Ms. Donna McGowan
TES VII Regional Project Officer
U.S. Environmental Protection Agency
841 Chestnut Street
Philadelphia, Pennsylvania 19107

PROJECT: EPA CONTRACT NO: 68-W9-0004

DOCUMENT NO: TES7-C03153-EP-DRBL

SUBJECT: Work Assignment C03153
Toxicological Data Management
Bell Landfill Risk Assessment
TES7-C03153-RT-DRBM

Dear Ms. McGowan:

Please find enclosed the Bell Landfill Risk Assessment report submitted as partial fulfillment if the reporting requirements for this work assignment. The report incorporates comments received from Reginald Harris of the Technical Support Section on December 12, 1993.

If you have any comments regarding this submittal, please contact me at (215) 293-0450 within two weeks of the date of this letter.

Sincerely,

CDM FEDERAL PROGRAMS CORPORATION (CDM Federal)

Mark diFeliciantonio
Regional Manager

cc: Dawn Ioven, EPA Work Assignment Manager, CERCLA Region III
Reginald Harris, Technical Support Section, CERCLA Region III
Jean Wright, TES VII Zone Project Officer (letter only)
Constance V. Braun, CDM Federal Program Manager

# TOXICOLOGICAL DATA MANAGEMENT
# BELL LANDFILL RISK ASSESSMENT

**Prepared for**

**U.S. ENVIRONMENTAL PROTECTION AGENCY**
**Office of Waste Programs Enforcement**
**Washington, D.C. 20460**

| | | |
|---|---|---|
| Work Assignment No. | : | C03153 |
| EPA Region | : | III |
| Site No. | : | |
| Contract No. | : | 68-W9-0004 |
| CDM FEDERAL PROGRAMS CORPORATION Document No. | : | TES7-C03153-RT-DRBM |
| Work Assignment Project Manager | : | Susan Insetta |
| Telephone Number | : | (215) 293-0450 |
| Primary Contact | : | Dawn Ioven |
| Telephone Number | : | (215) 597-1309 |
| Date Prepared | : | February 8, 1994 |

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# 1.0 INTRODUCTION

## 1.1 PURPOSE OF THE REPORT

CDM FEDERAL PROGRAMS CORPORATION (CDM Federal) received Work Assignment No. C03153 from the U.S. Environmental Protection Agency (EPA) under the TES VII Contract (EPA Contract No. 68-W9-0004). As part of this assignment, CDM Federal was tasked to perform portions of the human health risk assessment (RA) for the Bell Landfill Superfund Site (the "Site"). Specifically, EPA requested that CDM Federal perform the following tasks:

- prepare analytical summary tables for the Contaminants of Concern (COCs)
- provide pertinent information about the COCs, including frequency of detection and range of detected concentrations
- perform statistical analyses for the COCs, including the calculation of averages, standard deviations and 95th percent Upper Confidence Limits
- quantify risks based on a site conceptual model provided by EPA (Ioven 1993a).

## 1.2 REPORT FORMAT

This report is divided into five sections. Section 1.0, this section, is the introduction. Section 2.0 is the data evaluation. Data from the RI are tabulated, showing the occurrence and distribution of contaminants in the environmental media. From this list of organic and inorganic substances detected at the site, COCs are selected. Section 3.0 is the exposure assessment. Actual and potential exposure points, migration pathways and receptors are identified in the conceptual site model. Reasonable Maximum Exposure point concentrations (RMEs) are calculated for the pathways judged to be potentially complete. Section 4.0 is the toxicity assessment. EPA-approved toxicity factors are presented for the COCs. Section 5.0

is the risk characterization. The results of the data evaluation, exposure assessment and toxicity assessment are combined to quantify the current and future risks to human health posed by contaminants at the site.

## 2.0 DATA EVALUATION

Data evaluation entails the identification of substances present at the site that will be used in the risk assessment. The 33 acre site has been divided into two operable units (OU). OU-1 is comprised of two former municipal waste landfills and associated leachate collection drains and tanks. OU-2 encompasses two areas referred to as the debris area and drum area, site-wide groundwater and soil and two adjacent off-site surface water tributaries.

The remedial investigation (RI) field work for both OU-1 and OU-2 was conducted in September 1992. Data reported in the "Draft RI Report for Operable Unit One," December 18, 1992 (ERM, 1992), and the "Draft RI Report Operable Unit One, Addendum One," March 19, 1993 (ERM, 1993) were evaluated for the baseline risk assessment. Samples were collected from 13 surface soil locations, 3 leachate seeps, 2 leachate tanks, 8 surface water/sediment stations, 6 monitoring wells and 5 residential wells.

The organic and inorganic analyses of these samples and associated field blanks were performed by Lancaster Laboratories, Inc., Lancaster, Pennsylvania. Samples were analyzed for EPA Contract Laboratory Program (CLP) target compound list (TCL) volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), pesticides/PCBs and target analyte list (TAL) inorganics. All CLP sample analyses were performed according to protocols specified in the CLP statements of work for organic and inorganic analyses.

Data from these analyses were reviewed for adherence to the specified analytical protocols by Environmental Resources Management, Inc., Exton, Pennsylvania. The results were validated or qualified according to the "Laboratory Data Validation Functional Guidelines for Evaluating Organic and Inorganic Analyses," (EPA 1988 and July 1991a). Based on this review, it was concluded that both the organic and inorganic analyses were performed acceptably; however, some qualifying statements were required. Specifically, all tentatively identified compounds (TICs) were marked with a "JN" qualifier to indicate that they are quantitative estimates; all compounds that were qualitatively identified at concentrations

below their respective contract required detection limits (CRDLs) were qualified with a "J" to indicate that they are quantitative estimates; and some results were qualified with a "J" due to matrix interferences, comparisons to blind duplicates, positive interferences, instrument calibration response, duplicate analysis, precision criteria, or poor CRDL standard recoveries. Positive results for common laboratory contaminants that were detected at less than or equal to 10 times the method, field and/or travel blank contamination level were considered qualitatively invalid. Positive results for uncommon laboratory contaminants that were detected at less than or equal to 5 times the method, field and/or travel blank contamination level were considered qualitatively invalid. (This is an interpretation of the language in the QA report which refers to common laboratory contaminants when uncommon contaminants (i.e., gamma-chlordane) are presumably meant). Finally, dilutions of some samples to prevent instrument overload or due to poor spike recoveries resulted in high quantitation limits for some VOCs, SVOCs, and metals.

Data that were judged usable based on the validation process are summarized in **Table 1** showing all inorganic and organic parameters that were detected in at least one sample. Included in this group were unqualified results and results which were qualified with a "J" which means the chemical was present but the concentration was estimated. These values were used as actual detected concentrations which may have the effect of under- or overestimating the actual value. Sample results that were qualified with an "N", indicating presumptive evidence of the presence of that chemical in the sample, were not included in the list of chemicals of potential concern, since tentatively identified compounds (TICs) are not quantified and therefore not included in the risk assessment.

Table 1 shows the background concentration levels, the range of detections above the sample quantitation limit (SQL) by sample medium, arithmetic means of positive detections above the SQL, the number of detections above the SQL and the number of sample locations for each medium. Constituent concentrations for samples collected as duplicates were consolidated into a single value using the higher of the two detected concentrations. All other results represent a single sampling event.

Table 1
Occurrence and Distribution of Contaminants
Bell Landfill Site
Towanda, Pennsylvania

| Parameter | Media (1) | Minimum (2) | Maximum (2) | Average (3) | Detects (4) | Samples (5) | Background (6) | MCL (7) (ug/L) | 1E-6 / HQ 0.1 Risk Level (8) | COC |
|---|---|---|---|---|---|---|---|---|---|---|
| Aluminum | SS | 8820 | 13600 | 11005 | 13 | 13 | 12900 | | 23,000 | |
| | LS | 4000 | 12300 | 8247 | 3 | 3 | NA | NA | 110,000 | |
| | LT | 1500 | 1500 | 1500 | 1 | 1 | NA | | NA | |
| | SW | ND(19.0) | NA | NA | 0 | 6 | ND(19.0) | | 110,000 | |
| | SD | 6440 | 12900 | 9172 | 6 | 6 | 7610 | | 230,000 | |
| | MW | 1330 | 32800 | 15016 | 5 | 5 | 2450 | | 11,000 | Yes |
| | RES | ND(44.0) | NA | NA | 0 | 5 | NA | | 11,000 | |
| Antimony | SS | ND(1.3-1.8) | NA | NA | 0 | 13 | ND(1.4) | | 3.1 | |
| | LS | ND(16.0) | NA | NA | 0 | 3 | NA | | 15 | |
| | LT | 226 | 226 | 226 | 1 | 2 | NA | | NA | |
| | SW | 9 | 9 | 9 | 1 | 6 | ND(6.0) | | 15 | |
| | SD | ND(3.6-7.3) | NA | NA | 0 | 6 | ND(4.4-5.7) | | 31 | |
| | MW | ND(14.1) | NA | NA | 0 | 5 | ND(14.1) | 6 | 1.5 | |
| | RES | ND(16.0) | NA | NA | 0 | 5 | NA | 6 | 1.5 | |
| Arsenic | SS | 2.0 | 25.3 | 7.4 | 13 | 13 | 3.1 | | 2.3 | Yes |
| | LS | 5.9 | 23.1 | 15.7 | 3 | 3 | NA | | 11 | Yes |
| | LT | 7.7 | 7.7 | 7.7 | 1 | 1 | NA | | NA | |
| | SW | 1.2 | 1.3 | 1.3 | 2 | 6 | ND(1.0) | | 11 | |
| | SD | 2.6 | 8.1 | 5.4 | 6 | 6 | 5.0 | | 23 | |
| | MW | 4.2 | 31.3 | 17.0 | 4 | 5 | 3 | 50 | 1.1 | Yes |
| | RES | 1.2 | 2.6 | 1.9 | 2 | 5 | NA | 50 | 1.1 | Yes |
| Barium | SS | 84 | 1320 | 242 | 13 | 13 | 92 | | 550 | Yes |
| | LS | 151 | 2380 | 1577 | 3 | 3 | NA | | 2,600 | |
| | LT | 1930 | 2760 | 2345 | 2 | 2 | NA | | NA | |
| | SW | 29.4 | 50.6 | 35 | 6 | 6 | 28 | | 2,600 | |
| | SD | 66.2 | 196 | 127 | 6 | 6 | 116 | | 5,500 | |
| | MW | 53.3 | 908 | 466 | 5 | 5 | 84 | 2,000 | 260 | Yes |
| | RES | 37 | 213 | 107 | 5 | 5 | NA | 2,000 | 260 | |
| Beryllium | SS | 0.12 | 0.64 | 0.45 | 13 | 13 | 0.44 | | 0.15 | Yes |
| | LS | ND(1.0) | NA | NA | 0 | 3 | NA | | 0.16 | |
| | LT | ND(1.0-10.0) | NA | NA | 0 | 2 | NA | | NA | |
| | SW | ND(1.0) | NA | NA | 0 | 6 | ND(1.0) | | 0.16 | |
| | SD | 0.26 | 0.74 | 0.45 | 5 | 6 | 0.58 | | 1.5 | |
| | MW | 1.2 | 2.2 | 2.0 | 3 | 5 | ND(0.3) | 4 | 0.016 | Yes |
| | RES | ND(1.0) | NA | NA | 0 | 5 | NA | 4 | 0.016 | |
| Cadmium | SS | 3.4 | 134 | 35 | 8 | 10 | ND(0.23) | | 3.9 | Yes |
| | LS | 7.1 | 166 | 87 | 2 | 3 | NA | | 18 | Yes |
| | LT | 231 | 231 | 231 | 1 | 2 | NA | | NA | |
| | SW | ND(1.0) | NA | NA | 0 | 6 | ND(1.0) | | 18 | |
| | SD | 1.8 | 7.3 | 3.3 | 6 | 6 | 1.9 | | 39 | |
| | MW | ND(2.8) | NA | NA | 0 | 5 | ND(2.8) | 5 | 1.8 | |
| | RES | ND(4.0) | NA | NA | 0 | 5 | NA | 5 | 1.8 | |
| Calcium | SS | 1880 | 18800 | 7370 | 13 | 13 | 465 | | | |
| | LS | 15100 | 746000 | 345033 | 3 | 3 | NA | NA | NA | |
| | LT | 320000 | 1050000 | 685000 | 2 | 2 | NA | | | |
| | SW | 18800 | 23700 | 20733 | 6 | 6 | 19800 | | | |
| | SD | 1140 | 3930 | 2003 | 6 | 6 | 1670 | | | |
| | MW | 39000 | 75700 | 59000 | 5 | 5 | 41800 | | | |
| | RES | 28700 | 39300 | 35080 | 5 | 5 | NA | | | |

**Table 1 (continued)**
**Occurrence and Distribution of Contaminants**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Parameter | Media (1) | Minimum (2) | Maximum (2) | Average (3) | Detects (4) | Samples (5) | Background (6) | MCL (7) (ug/L) | 1E−6 / HQ 0.1 Risk Level (8) | COC |
|---|---|---|---|---|---|---|---|---|---|---|
| Chromium | SS | 15.9 | 39.1 | 25.5 | 13 | 13 | 17.1 | | 39 | Yes |
| | LS | 17.4 | 227.0 | 106.0 | 3 | 3 | NA | | 180 | Yes |
| | LT | 78.4 | 275.0 | 176.7 | 2 | 2 | NA | | NA | |
| | SW | NA | NA | NA | 0 | 6 | ND(1.0) | | 180 | |
| | SD | 7.4 | 13 | 9.7 | 6 | 6 | 7.7 | | 390 | |
| | MW | 9.3 | 161.0 | 56.0 | 4 | 5 | 18.2 | 100 | 18 | Yes |
| | RES | ND(6.0) | NA | NA | 0 | 5 | NA | 100 | 18 | |
| Cobalt | SS | 9.8 | 117 | 46 | 13 | 13 | 7.8 | | | |
| | LS | 14.6 | 1440 | 587 | 3 | 3 | NA | NA | NA | Yes ** |
| | LT | 216 | 2500 | 1358 | 2 | 2 | NA | | | |
| | SW | NA | NA | NA | 0 | 6 | ND(2.0) | | | |
| | SD | 5.6 | 13.8 | 9.7 | 6 | 6 | 9 | | | |
| | MW | 2.8 | 31.2 | 13.0 | 4 | 5 | 2.7 | | | |
| | RES | ND(4.0) | NA | NA | 0 | 5 | NA | | | |
| Copper | SS | 10.4 | 81.4 | 28.1 | 13 | 13 | 9.6 | | 290 | |
| | LS | 11.2 | 126 | 67.7 | 3 | 3 | NA | | 1,400 | |
| | LT | 44.5 | 44.5 | 44.5 | 1 | 2 | NA | | NA | |
| | SW | ND(5.0) | NA | NA | 0 | 6 | ND(5.0) | | 1,400 | |
| | SD | 9.7 | 9.7 | 9.7 | 1 | 1 | B | (MCLG) | 2,900 | |
| | MW | 74.6 | 241 | 158.0 | 2 | 2 | B | 1,300 | 140 | Yes |
| | RES | 42.6 | 42.6 | 42.6 | 1 | 2 | NA | 1,300 | 140 | |
| Cyanide | SS | ND(0.28−0.47) | NA | NA | 0 | 13 | ND(0.3) | | 160 | |
| | LS | 3.5 | 6.1 | 4.8 | 2 | 3 | NA | | 730 | |
| | LT | 6.9 | 6.9 | 6.9 | 1 | 2 | NA | | NA | |
| | SW | ND(2.5) | NA | NA | 0 | 6 | ND(2.5) | | 730 | |
| | SD | ND(0.31−0.57) | NA | NA | 0 | 6 | ND(0.35−0.44) | | 1,600 | |
| | MW | NA | NA | NA | 0 | 0 | NA | 200 | 73 | |
| | RES | ND(2.5) | NA | NA | 0 | 5 | NA | 200 | 73 | |
| Iron | SS | 14800 | 45100 | 30584 | 13 | 13 | 16400 | | | |
| | LS | 23600 | 766000 | 359200 | 3 | 3 | NA | NA | NA | |
| | LT | 278000 | 921000 | 599500 | 2 | 2 | NA | | | |
| | SW | 206 | 582 | 353 | 3 | 6 | 1300 | | | |
| | SD | 13300 | 27800 | 20617 | 6 | 6 | 18300 | | | |
| | MW | 1650 | 69900 | 23894 | 5 | 5 | 2660 | | | |
| | RES | 838 | 838 | 838 | 1 | 1 | NA | | | |
| Lead | SS | 9.4 | 7840 | 644 | 13 | 13 | 12.5 | | | Yes |
| | LS | 6.1 | 30 | 15.9 | 3 | 3 | NA | | NA | |
| | LT | 3 | 3 | 3 | 1 | 1 | NA | | | |
| | SW | 2.2 | 2.2 | 2.2 | 1 | 6 | ND(1.0) | | | |
| | SD | 14.6 | 14.6 | 14.6 | 1 | 1 | B | (TT) | | |
| | MW | 0.93 | 50.6 | 20 | 4 | 5 | 0.55 | 15 | | Yes |
| | RES | ND(1.0−5.0) | NA | NA | 0 | 5 | NA | 15 | | |
| Magnesium | SS | 2630 | 4780 | 3723 | 13 | 13 | 2580 | | | |
| | LS | 4490 | 244000 | 99597 | 3 | 3 | NA | NA | NA | |
| | LT | 58800 | 322000 | 190400 | 2 | 2 | NA | | | |
| | SW | 2040 | 4030 | 3037 | 6 | 6 | 2665 | | | |
| | SD | 2020 | 3390 | 2730 | 6 | 6 | 2540 | | | |
| | MW | 5770 | 17200 | [illegible] | [illegible] | [illegible] | [illegible] | | | |

Table (continued)
Occurrence and Distribution of Contaminants
Bell Landfill Site
Towanda, Pennsylvania

| Parameter | Media (1) | Minimum (2) | Maximum (2) | Average (3) | Detects (4) | Samples (5) | Background (6) | MCL (7) (ug/L) | 1E-6 / HQ 0.1 Risk Level (8) | COC |
|---|---|---|---|---|---|---|---|---|---|---|
| Manganese | SS | 36.5 | 10100 | 3246 | 13 | 13 | 1340 | | 39 | Yes |
| | LS | 5860 | 108000 | 60893 | 3 | 3 | NA | NA | 180 | Yes |
| | LT | 73400 | 163000 | 118200 | 2 | 2 | NA | | NA | |
| | SW | 2.6 | 796 | 190 | 6 | 6 | 194.7 | | 180 | Yes |
| | SD | 587 | 3620 | 1585 | 6 | 6 | 2060 | | 390 | Yes |
| | MW | 56.6 | 1950 | 1014 | 5 | 5 | 136 | | 18 | Yes |
| | RES | 31.2 | 54 | 43 | 2 | 5 | NA | | 18 | Yes |
| Mercury | SS | 0.05 | 2.40 | 0.36 | 11 | 13 | 0.06 | | 2.3 | Yes |
| | LS | B | NA | NA | 0 | 0 | NA | | 11 | |
| | LT | B | NA | NA | 0 | 0 | NA | | NA | |
| | SW | ND(0.10) | NA | NA | 0 | 6 | ND(0.10) | | 11 | |
| | SD | 0.08 | 0.13 | 0.11 | 2 | 6 | ND(0.05-0.08) | | 23 | |
| | MW | ND(0.06) | NA | NA | 0 | 4 | ND(0.06) | 2 | 1.1 | |
| | RES | ND(0.10) | NA | NA | 0 | 5 | NA | 2 | 1.1 | |
| Molybdenum | SS | NA | NA | NA | 0 | 0 | NA | | 39 | |
| | LS | 1750 | 1800 | 1775 | 2 | 2 | NA | NA | 180 | Yes |
| | LT | 944 | 3010 | 1977 | 2 | 2 | NA | | NA | |
| | SW | NA | NA | NA | 0 | 0 | NA | | 180 | |
| | SD | NA | NA | NA | 0 | 0 | NA | | 390 | |
| | MW | NA | NA | NA | 0 | 0 | NA | | 18 | |
| | RES | NA | NA | NA | 0 | 0 | NA | | 18 | |
| Nickel | SS | 17.3 | 43.5 | 30.5 | 11 | 11 | 14.4 | | 160 | |
| | LS | 12.8 | 306 | 161 | 3 | 3 | NA | | 730 | |
| | LT | 122 | 486 | 304 | 2 | 2 | NA | | NA | |
| | SW | ND(4.0) | NA | NA | 0 | 6 | ND(4.0) | | 730 | |
| | SD | 9.2 | 17.8 | 14.2 | 6 | 6 | 12.7 | | 1,600 | |
| | MW | 4.6 | 140 | 49.0 | 4 | 5 | 15.4 | 100 | 73 | Yes |
| | RES | ND(7.0) | NA | NA | 0 | 4 | NA | 100 | 73 | |
| Potassium | SS | 676 | 1600 | 992 | 13 | 13 | 636 | | | |
| | LS | 4050 | 254000 | 95383 | 3 | 3 | NA | NA | NA | |
| | LT | 26200 | 338000 | 182100 | 2 | 2 | NA | | | |
| | SW | 834 | 2120 | 1419 | 6 | 6 | 951 | | | |
| | SD | 554 | 948 | 765 | 6 | 6 | 576 | | | |
| | MW | 1220 | 15500 | 5808 | 5 | 5 | 1390 | | | |
| | RES | 619 | 1800 | 1210 | 2 | 2 | NA | | | |
| Selenium | SS | 0.29 | 0.37 | 0.31 | 4 | 13 | ND(0.24) | | 39 | |
| | LS | ND(1.0-5.0) | NA | NA | 0 | 3 | NA | | 180 | |
| | LT | ND(5.0-10.0) | NA | NA | 0 | 2 | NA | | NA | |
| | SW | NA | NA | NA | 0 | 6 | ND(1.0) | | 180 | |
| | SD | 0.5 | 0.5 | 0.5 | 1 | 6 | ND(0.27-0.34) | | 390 | |
| | MW | ND(0.9-1.6) | NA | NA | 0 | 5 | ND(1.6) | 50 | 18 | |
| | RES | 3.2 | 3.2 | 3.2 | 1 | 5 | NA | 50 | 18 | |
| Silver | SS | 1.9 | 5.9 | 3.9 | 13 | 13 | 2.2 | | 39 | |
| | LS | 38.3 | 97.1 | 67.7 | 2 | 3 | NA | NA | 180 | |
| | LT | 59.4 | 101 | 80 | 2 | 2 | NA | | NA | |
| | SW | ND(6.0) | NA | NA | 0 | 6 | ND(6.0) | | 180 | |
| | SD | 1.9 | 1.9 | 1.9 | 1 | 6 | 19.4 | | 390 | |
| | MW | ND(3.1) | NA | NA | 0 | 5 | ND(3.1) | | 18 | |
| | RES | ND(4.0) | NA | NA | 0 | 5 | NA | | 18 | |

**Table 1 (continued)**
**Occurrence and Distribution of Contaminants**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Parameter | Media (1) | Minimum (2) | Maximum (2) | Average (3) | Detects (4) | Samples (5) | Background (6) | MCL (7) (ug/L) | 1E-6 / HQ 0.1 Risk Level (8) | COC |
|---|---|---|---|---|---|---|---|---|---|---|
| Sodium | SS | 218 | 1390 | 607 | 7 | 7 | B | | | |
| | LS | 2000 | 925000 | 367000 | 3 | 3 | NA | NA | NA | |
| | LT | 189000 | 1300000 | 744500 | 2 | 2 | NA | | | |
| | SW | 2800 | 183000 | 35765 | 6 | 6 | 2960 | | | |
| | SD | 56.9 | 139 | 98 | 2 | 6 | 66.6 | | | |
| | MW | 4920 | 22700 | 9760 | 5 | 5 | 4050 | | | |
| | RES | 4200 | 14500 | 8614 | 5 | 5 | NA | | | |
| Thallium | SS | ND(0.44-0.67) | NA | NA | 0 | 13 | ND(0.48) | | 0.63 | |
| | LS | ND(2.0-10.0) | NA | NA | 0 | 3 | NA | 2 | 2.9 | |
| | LT | ND(2.0-10.0) | NA | NA | 0 | 2 | NA | | NA | |
| | SW | ND(2.0) | NA | NA | 0 | 1 | ND(2.0) | | 2.9 | |
| | SD | ND(0.47-0.91) | NA | NA | 0 | 6 | ND(0.54-0.67) | | 6.3 | |
| | MW | ND(1.9-3.8) | NA | NA | 0 | 5 | ND(1.9) | | 0.29 | |
| | RES | ND(2.0) | NA | NA | 0 | 2 | NA | | 0.29 | |
| Vanadium | SS | 12.2 | 23.2 | 17.7 | 13 | 13 | 17 | | 55 | |
| | LS | 17.3 | 51.3 | 35.8 | 3 | 3 | NA | NA | 260 | |
| | LT | 23.1 | 115 | 69.1 | 2 | 2 | NA | | NA | |
| | SW | ND(2.0) | NA | NA | 0 | 6 | ND(2.0) | | 260 | |
| | SD | 11.6 | 21.8 | 16.4 | 6 | 6 | 13.8 | | 550 | |
| | MW | 3.0 | 45.8 | 25.0 | 4 | 5 | 3.4 | | 26 | Yes |
| | RES | ND(5.0) | NA | NA | 0 | 5 | NA | | 26 | |
| Zinc | SS | 68.5 | 512 | 166 | 13 | 13 | 63.9 | | 2,300 | |
| | LS | 309 | 1680 | 995 | 2 | 2 | NA | NA | 11,000 | |
| | LT | 2450 | 2450 | 2450 | 1 | 2 | NA | | NA | |
| | SW | 8.2 | 8.5 | 8.4 | 2 | 6 | 7.0 | | 11,000 | |
| | SD | 53.1 | 104 | 76 | 3 | 3 | 61.1 | | 23,000 | |
| | MW | 8.1 | 174 | 63 | 5 | 5 | 18.3 | | 1,100 | |
| | RES | ND(3.0) | NA | NA | 0 | 2 | NA | | 1,100 | |
| 1,1,1-Trichloroethane | SS | 3.0 | 7.0 | 4.7 | 6 | 13 | 8.0 | | 700,000 | |
| | LS | ND(10-2500) | NA | NA | 0 | 3 | NA | | 1,300 | |
| | LT | ND(10-500) | NA | NA | 0 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | 1,300 | |
| | SD | ND(12-24) | NA | NA | 0 | 6 | ND(14-18) | | 7,000,000 | |
| | MW | ND(10) | NA | NA | 0 | 5 | ND(10) | 200 | 130 | |
| | RES | 1.2 | 1.2 | 1.2 | 1 | 5 | NA | 200 | 130 | |
| 1,1-Dichloroethane | SS | 2 | 2 | 2 | 1 | 13 | ND(12) | | 780,000 | |
| | LS | 23 | 23 | 23 | 1 | 3 | NA | NA | 810 | |
| | LT | 19 | 160 | 90 | 2 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | 810 | |
| | SD | ND(12-24) | NA | NA | 0 | 6 | ND(14-18) | | 7,800,000 | |
| | MW | ND(10) | NA | NA | 0 | 5 | ND(10) | | 81 | |
| | RES | ND(1.0) | NA | NA | 0 | 5 | NA | | 81 | |
| 1,2-Dichloroethene (total) | SS | ND(11-18) | NA | NA | 0 | 13 | ND(12) | | 70,000 | |
| | LS | 590 | 590 | 590 | 1 | 3 | NA | | 55 | Yes |
| | LT | 72 | 86 | 79 | 2 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | 55 | |
| | SD | ND(12-24) | NA | NA | 0 | 6 | ND(14-18) | (cis/trans) | 700,000 | |
| | MW * | 10 | 13 | 11.5 | 2 | 5 | ND(10) | 70/100 | 5.5 | |
| | RES | | | | | | | | | |

Table 1 (continued)
Occurrence and Distribution of Contaminants
Bell Landfill Site
Towanda, Pennsylvania

| Parameter | Media (1) | Minimum (2) | Maximum (2) | Average (3) | Detects (4) | Samples (5) | Background (6) | MCL (7) (ug/L) | 1E-6 / HQ 0.1 Risk Level (8) | COC |
|---|---|---|---|---|---|---|---|---|---|---|
| 2-Butanone (Methyl Ethyl Ketone, MEK) | SS | 11 | 790 | 252 | 5 | 11 | ND(12) | | 4,700,000 | |
| | LS | 1400 | 5400 | 3400 | 2 | 3 | NA | NA | 22,000 | |
| | LT | 1500 | 8200 | 4850 | 2 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | 22,000 | |
| | SD | 16 | 62 | 39 | 2 | 6 | 16.5 | | 47,000,000 | |
| | MW | ND(10) | NA | NA | 0 | 5 | ND(10) | | 2,200 | |
| | RES | ND(5.0) | NA | NA | 0 | 5 | NA | | 2,200 | |
| 2-Hexanone (Methyl Butyl Ketone, MBK) | SS | 7 | 13 | 10 | 2 | 13 | ND(12) | | | |
| | LS | 73 | 73 | 73 | 1 | 3 | NA | NA | NA | |
| | LT | 240 | 240 | 240 | 1 | 2 | NA | | | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | | |
| | SD | ND(12-24) | NA | NA | 0 | 6 | ND(14-18) | | | |
| | MW | ND(10) | NA | NA | 0 | 5 | ND(10) | | | |
| | RES | ND(5.0) | NA | NA | 0 | 5 | NA | | | |
| 4-Methyl-2-Pentanone | SS | 15 | 65 | 40 | 2 | 13 | ND(12) | | 3,900,000 | |
| | LS | 380 | 380 | 380 | 1 | 3 | NA | NA | 1,800 | |
| | LT | 280 | 490 | 385 | 2 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | 1,800 | |
| | SD | ND(12-24) | NA | NA | 0 | 6 | ND(14-18) | | 39,000,000 | |
| | MW | 2 | 5 | 4 | 2 | 5 | ND(10) | | 180 | |
| | RES | ND(5.0) | NA | NA | 0 | 5 | NA | | 180 | |
| Acetone | SS | 28 | 890 | 228 | 8 | 9 | B | | 780,000 | |
| | LS | 3400 | 5400 | 4400 | 2 | 3 | NA | NA | 3,700 | Yes |
| | LT | 4400 | 6800 | 5600 | 2 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | 3,700 | |
| | SD | 8 | 180 | 69 | 5 | 6 | 56.5 | | 7,800,000 | |
| | MW | ND(10) | NA | NA | 0 | 5 | ND(10-86) | | 370 | |
| | RES | 12 | 12 | 12 | 1 | 5 | NA | | 370 | |
| Benzene | SS | 1 | 1 | 1 | 1 | 13 | ND(12) | | 22,000 | |
| | LS | 13 | 13 | 13 | 1 | 3 | NA | | 3.6 | Yes |
| | LT | 21 | 21 | 21 | 1 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | 3.6 | |
| | SD | ND(12-24) | NA | NA | 0 | 6 | ND(14-18) | | 220,000 | |
| | MW | 1 | 1 | 1 | 1 | 5 | ND(10) | 5 | 0.36 | Yes |
| | RES | ND(1.0) | NA | NA | 0 | 5 | NA | 5 | 0.36 | |
| Carbon Disulfide | SS | 1 | 2 | 2 | 2 | 11 | ND(12) | | 780,000 | |
| | LS | ND(10-2500) | NA | NA | 0 | 3 | NA | NA | 21 | |
| | LT | ND(10-500) | NA | NA | 0 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | 21 | |
| | SD | 3 | 3 | 3 | 1 | 6 | 2 | | 7,800,000 | |
| | MW | ND(10) | NA | NA | 0 | 5 | ND(10) | | 2.1 | |
| | RES | ND(1.0) | NA | NA | 0 | 5 | NA | | 2.1 | |
| Ethylbenzene | SS | 3 | 120 | 48 | 5 | 13 | ND(12) | | 780,000 | |
| | LS | 39 | 820 | 430 | 2 | 3 | NA | | 1,300 | |
| | LT | 26 | 1200 | 613 | 2 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | 1,300 | |
| | SD | ND(12-24) | NA | NA | 0 | 6 | ND(14-18) | | 7,800,000 | |
| | MW | ND(10) | NA | NA | 0 | 5 | ND(10) | 700 | 130 | |
| | RES | ND(1.0) | NA | NA | 0 | 5 | NA | 700 | | |

Table 1 (continued)
Occurrence and Distribution of Contaminants
Bell Landfill Site
Towanda, Pennsylvania

| Parameter | Media (1) | Minimum (2) | Maximum (2) | Average (3) | Detects (4) | Samples (5) | Background (6) | MCL (7) (ug/L) | 1E-6 / HQ 0.1 Risk Level (8) | COC |
|---|---|---|---|---|---|---|---|---|---|---|
| Methylene Chloride | SS | B | NA | NA | 0 | 0 | B | | 85,000 | |
| | LS | 580 | 28000 | 14290 | 2 | 3 | NA | | 41 | Yes |
| | LT | 47 | 44000 | 22024 | 2 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | 3 | | 41 | |
| | SD | 2 | 3 | 3 | 2 | 6 | ND(14-18) | | 850,000 | |
| | MW | ND(10) | NA | NA | 0 | 5 | ND(10) | 5 | 4.1 | |
| | RES | ND(1.0-2.0) | NA | NA | 0 | 5 | NA | 5 | 4.1 | |
| Tetrachloroethene | SS | ND(11-18) | NA | NA | 0 | 13 | ND(12) | | 12,000 | |
| | LS | ND(10-2500) | NA | NA | 0 | 3 | NA | | 11 | |
| | LT | 1 | 1 | 1 | 1 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | 11 | |
| | SD | ND(12-24) | NA | NA | 0 | 6 | ND(14-18) | | 120,000 | |
| | MW * | 3.4 | 5.8 | 4.6 | 2 | 5 | ND(10) | 5 | 1.1 | Yes |
| | RES | ND(1.0) | NA | NA | 0 | 5 | NA | 5 | 1.1 | |
| Toluene | SS | 6 | 250 | 114 | 6 | 13 | ND(12) | | 1,600,000 | |
| | LS | 51 | 920 | 624 | 3 | 3 | NA | | 750 | Yes |
| | LT | 470 | 980 | 725 | 2 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | 750 | |
| | SD | 13 | 89 | 51 | 2 | 6 | ND(14-18) | | 16,000,000 | |
| | MW | 3 | 12 | 8 | 2 | 5 | ND(10) | 1,000 | 75 | |
| | RES | ND(1.0) | NA | NA | 0 | 5 | NA | 1,000 | 75 | |
| Trichloroethene | SS | 4 | 4 | 4 | 2 | 13 | ND(12) | | 58,000 | |
| | LS | 340 | 350 | 345 | 2 | 3 | NA | | 16 | Yes |
| | LT | 19 | 490 | 255 | 2 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | 16 | |
| | SD | ND(12-24) | NA | NA | 0 | 6 | ND(14-18) | | 580,000 | |
| | MW * | 23 | 25 | 24 | 2 | 5 | ND(10) | 5 | 1.6 | Yes |
| | RES | ND(1.0) | NA | NA | 0 | 5 | NA | 5 | 1.6 | |
| Vinyl Chloride | SS | ND(11-18) | NA | NA | 0 | 13 | ND(12) | | 340 | |
| | LS | 44 | 44 | 44 | 1 | 3 | NA | | 0.19 | Yes |
| | LT | 22 | 22 | 22 | 1 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | 0.19 | |
| | SD | ND(12-24) | NA | NA | 0 | 6 | ND(14-18) | | 3,400 | |
| | MW * | 2 | 5 | 4 | 2 | 5 | ND(10) | 2 | 0.019 | Yes |
| | RES | ND(1.0) | NA | NA | 0 | 5 | NA | 2 | 0.019 | |
| Xylene (total) | SS | 11 | 560 | 218 | 5 | 13 | ND(12) | | 16,000,000 | |
| | LS | 170 | 3400 | 1785 | 2 | 3 | NA | | 12,000 | |
| | LT | 77 | 4500 | 2289 | 2 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | 12,000 | |
| | SD | ND(12-24) | NA | NA | 0 | 6 | ND(14-18) | | 160,000,000 | |
| | MW | 1 | 1 | 1 | 2 | 5 | ND(10) | 10,000 | 1,200 | |
| | RES | ND(1.0) | NA | NA | 0 | 5 | NA | 10,000 | 1,200 | |
| 4,4'-DDD | SS | 3.1 | 3.1 | 3.1 | 1 | 13 | ND(4.0) | | 2,700 | |
| | LS | ND(0.1-1.0) | NA | NA | 0 | 3 | NA | NA | 2.8 | |
| | LT | ND(0.1-1.0) | NA | NA | 0 | 2 | NA | | NA | |
| | SW | ND(0.10) | NA | NA | 0 | 6 | ND(0.10) | | 2.8 | |
| | SD | 1.4 | 1.9 | 1.7 | 2 | 6 | 2.8 | | 27,000 | |
| | MW | ND(0.10) | NA | NA | 0 | 5 | ND(0.10) | | 0.28 | |
| | RES | NA | NA | NA | | | | | | |

Table 1 (continued)
Occurrence and Distribution of Contaminants
Bell Landfill Site
Towanda, Pennsylvania

| Parameter | Media (1) | Minimum (2) | Maximum (2) | Average (3) | Detects (4) | Samples (5) | Background (6) | MCL (7) (ug/L) | 1E-6 / HQ 0.1 Risk Level (8) | COC |
|---|---|---|---|---|---|---|---|---|---|---|
| 4,4'-DDE | SS | 1.1 | 1.1 | 1.1 | 1 | 13 | ND(4.0) | | 1,900 | |
| | LS | ND(0.1-1.0) | NA | NA | 0 | 3 | NA | NA | 2 | |
| | LT | ND(0.1-1.0) | NA | NA | 0 | 2 | NA | | NA | |
| | SW | ND(0.10) | NA | NA | 0 | 6 | ND(0.10) | | 2 | |
| | SD | 2.1 | 2.1 | 2.1 | 1 | 6 | ND(4.6-6.0) | | 19,000 | |
| | MW | ND(0.10) | NA | NA | 0 | 5 | ND(0.10) | | 0.2 | |
| | RES | NA | NA | NA | 0 | 0 | NA | | 0.2 | |
| 4,4'-DDT | SS | 1.4 | 30 | 10.0 | 4 | 13 | 0.79 | | 1,900 | |
| | LS | 0.05 | 0.50 | 0.28 | 2 | 3 | NA | NA | 2 | |
| | LT | ND(0.1-1.0) | NA | NA | 0 | 2 | NA | | NA | |
| | SW | ND(0.10) | NA | NA | 0 | 6 | ND(0.10) | | 2 | |
| | SD | 1.1 | 12 | 6.6 | 2 | 6 | 22 | | 19,000 | |
| | MW | ND(0.10) | NA | NA | 0 | 5 | ND(0.10) | | 0.2 | |
| | RES | NA | NA | NA | 0 | 0 | NA | | 0.2 | |
| Aldrin | SS | 19.5 | 23 | 21.3 | 2 | 13 | ND(2.0) | | 38 | |
| | LS | ND(0.05-0.5) | NA | NA | 0 | 3 | NA | NA | 0.04 | |
| | LT | ND(0.05-0.5) | NA | NA | 0 | 2 | NA | | NA | |
| | SW | ND(0.050) | NA | NA | 0 | 6 | ND(0.050) | | 0.04 | |
| | SD | ND(2.1-4.0) | NA | NA | 0 | 6 | ND(2.4-3.1) | | 380 | |
| | MW | ND(0.050) | NA | NA | 0 | 5 | ND(0.050) | | 0.004 | |
| | RES | NA | NA | NA | 0 | 0 | NA | | 0.004 | |
| Arocior-1242 | SS | 73 | 73 | 73 | 1 | 13 | ND(40) | | 83 | |
| | LS | ND(1.0-10) | NA | NA | 0 | 3 | NA | | 0.087 | |
| | LT | ND(1.0-10) | NA | NA | 0 | 2 | NA | | NA | |
| | SW | ND(1.0) | NA | NA | 0 | 6 | ND(1.0) | | 0.087 | |
| | SD | ND(41-78) | NA | NA | 0 | 6 | ND(46-60) | | 830 | |
| | MW | ND(1.0) | NA | NA | 0 | 5 | ND(1.0) | 0.5 | 0.0087 | |
| | RES | NA | NA | NA | 0 | 0 | NA | 0.5 | 0.0087 | |
| Dieldrin | SS | 0.71 | 0.85 | 0.78 | 2 | 13 | ND(4.0-6.0) | | 40 | |
| | LS | ND(0.1-1.0) | NA | NA | 0 | 3 | NA | NA | 0.042 | |
| | LT | ND(0.1-1.0) | NA | NA | 0 | 2 | NA | | NA | |
| | SW | ND(0.10) | NA | NA | 0 | 6 | ND(0.10) | | 0.042 | |
| | SD | ND(4.1-7.8) | NA | NA | 0 | 6 | ND(4.6-6.0) | | 400 | |
| | MW | ND(0.10) | NA | NA | 0 | 5 | ND(0.10) | | 0.0042 | |
| | RES | NA | NA | NA | 0 | 0 | NA | | 0.0042 | |
| Heptachlor epoxide | SS | ND(1.9-3.2) | NA | NA | 0 | 13 | ND(2.0) | | 70 | |
| | LS | 0.021 | 0.021 | 0.021 | 1 | 3 | NA | 0.2 | 0.012 | Yes |
| | LT | ND(0.042-0.5) | NA | NA | 0 | 2 | NA | | NA | |
| | SW | ND(0.050) | NA | NA | 0 | 6 | ND(0.050) | | 0.012 | |
| | SD | ND(2.1-4.0) | NA | NA | 0 | 6 | ND(2.4-3.1) | | 700 | |
| | MW | ND(0.050) | NA | NA | 0 | 5 | ND(0.050) | 0.2 | 0.0012 | |
| | RES | NA | NA | NA | 0 | 0 | NA | 0.2 | 0.0012 | |
| Methoxychlor | SS | 3.6 | 3.6 | 3.6 | 1 | 13 | ND(20) | | 39,000 | |
| | LS | ND(0.5-5.0) | NA | NA | 0 | 3 | NA | | 180 | |
| | LT | ND(0.5-5.0) | NA | NA | 0 | 2 | NA | | NA | |
| | SW | 0.048 | 0.048 | 0.048 | 1 | 6 | ND(0.50) | | 180 | |
| | SD | ND(21-40) | NA | NA | 0 | 6 | ND(24-31) | | 390,000 | |
| | MW | ND(0.50) | NA | NA | 0 | 5 | ND(0.50) | 40 | 18 | |
| | RES | NA | NA | NA | 0 | 0 | NA | 40 | 18 | |

**Table 1 (continued)**
**Occurrence and Distribution of Contaminants**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Parameter | Media (1) | Minimum (2) | Maximum (2) | Average (3) | Detects (4) | Samples (5) | Background (6) | MCL (7) (ug/L) | 1E-6 / HQ 0.1 Risk Level (8) | COC |
|---|---|---|---|---|---|---|---|---|---|---|
| delta-BHC | SS | 1.1 | 9.7 | 4.4 | 6 | 13 | ND(2.0) | | | |
| | LS | 0.17 | 4.7 | 2.4 | 2 | 3 | NA | NA | NA | Yes ** |
| | LT | 5.3 | 5.3 | 5.3 | 1 | 2 | NA | | | |
| | SW | ND(0.050) | NA | NA | 0 | 6 | ND(0.050) | | | |
| | SD | ND(2.1-4.0) | NA | NA | 0 | 6 | ND(2.4-3.1) | | | |
| | MW | ND(0.050) | NA | NA | 0 | 5 | ND(0.050) | | | |
| | RES | NA | NA | NA | 0 | 0 | NA | | | |
| alpha-Chlordane | SS | ND(1.9-2.5) | NA | NA | 0 | 13 | ND(2.0) | | 490 | |
| | LS | ND(0.050-0.50) | NA | NA | 0 | 3 | NA | | 0.52 | |
| | LT | ND(0.050-0.50) | NA | NA | 0 | 2 | NA | | NA | |
| | SW | ND(0.050) | NA | NA | 0 | 6 | ND(0.050) | | 0.52 | |
| | SD | ND(2.1-4.0) | NA | NA | 0 | 6 | ND(2.4-3.1) | | 4,900 | |
| | MW | ND(0.050) | NA | NA | 0 | 5 | ND(0.050) | 2 | 0.052 | |
| | RES | NA | NA | NA | 0 | 0 | NA | 2 | 0.052 | |
| 1,2-Dichlorobenzene | SS | ND(380-610) | NA | NA | 0 | 13 | ND(400) | | 700,000 | |
| | LS | ND(10-500) | NA | NA | 0 | 3 | NA | | 370 | |
| | LT | ND(200-1200) | NA | NA | 0 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | 370 | |
| | SD | ND(410-780) | NA | NA | 0 | 6 | ND(460-600) | | 7,000,000 | |
| | MW | ND(10-20) | NA | NA | 0 | 5 | ND(10) | 600 | 37 | |
| | RES | 0.2 | 0.2 | 0.2 | 1 | 5 | NA | 600 | 37 | |
| 2-Methylphenol | SS | ND(380-610) | NA | NA | 0 | 13 | ND(400) | | 390,000 | |
| | LS | 83 | 83 | 83 | 1 | 3 | NA | NA | 1,800 | |
| | LT | 60 | 60 | 60 | 1 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | 1,800 | |
| | SD | ND(410-780) | NA | NA | 0 | 6 | ND(460-600) | | 3,900,000 | |
| | MW | ND(10-20) | NA | NA | 0 | 5 | ND(10) | | 180 | |
| | RES | ND(5.0) | NA | NA | 0 | 5 | NA | | 180 | |
| 2-Nitrophenol | SS | 490 | 490 | 490 | 1 | 13 | ND(400) | | | |
| | LS | ND(10-500) | NA | NA | 0 | 3 | NA | NA | NA | |
| | LT | ND(200-1200) | NA | NA | 0 | 2 | NA | | | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | | |
| | SD | ND(410-780) | NA | NA | 0 | 6 | ND(460-600) | | | |
| | MW | ND(10-20) | NA | NA | 0 | 5 | ND(10) | | | |
| | RES | ND(5.0) | NA | NA | 0 | 5 | NA | | | |
| 4-Methylphenol | SS | 53 | 750 | 428 | 3 | 13 | ND(400) | | 39,000 | |
| | LS | 1500 | 3600 | 2650 | 2 | 3 | NA | NA | 180 | Yes |
| | LT | 1600 | 2800 | 2200 | 2 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | 180 | |
| | SD | ND(410-780) | NA | NA | 0 | 6 | ND(460-600) | | 390,000 | |
| | MW | 2 | 2 | 2 | 1 | 5 | ND(10) | | 18 | |
| | RES | ND(5.0) | NA | NA | 0 | 5 | NA | | 18 | |
| 4-Nitrophenol | SS | 530 | 530 | 530 | 1 | 13 | ND(1000) | | 480,000 | |
| | LS | ND(25-1200) | NA | NA | 0 | 3 | NA | NA | 2,300 | |
| | LT | ND(500-3100) | NA | NA | 0 | 2 | NA | | NA | |
| | SW | ND(25) | NA | NA | 0 | 6 | ND(25) | | 2,300 | |
| | SD | ND(1000-2000) | NA | NA | 0 | 6 | ND(1200-1500) | | 4,800,000 | |
| | MW | ND(25-50) | NA | NA | 0 | 5 | ND(25) | | 230 | |

Table (continued)
Occurrence and Distribution of Contaminants
Bell Landfill Site
Towanda, Pennsylvania

| Parameter | Media (1) | Minimum (2) | Maximum (2) | Average (3) | Detects (4) | Samples (5) | Background (6) | MCL (7) (ug/L) | 1E-6 / HQ 0.1 Risk Level (8) | COC |
|---|---|---|---|---|---|---|---|---|---|---|
| Benzo(a)anthracene | SS | 66 | 66 | 66 | 1 | 13 | ND(400) | | 870 | |
| | LS | ND(10-500) | NA | NA | 0 | 3 | NA | NA | 0.92 | |
| | LT | ND(200-1200) | NA | NA | 0 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | 0.92 | |
| | SD | ND(410-780) | NA | NA | 0 | 6 | ND(460-600) | | 8,700 | |
| | MW | ND(10-20) | NA | NA | 0 | 5 | ND(10) | | 0.092 | |
| | RES | ND(5.0) | NA | NA | 0 | 5 | NA | | 0.092 | |
| Benzo(a)pyrene | SS | 120 | 120 | 120 | 1 | 13 | ND(400) | | 88 | Yes |
| | LS | ND(10-500) | NA | NA | 0 | 3 | NA | | 0.092 | |
| | LT | ND(200-1200) | NA | NA | 0 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | 0.092 | |
| | SD | 240 | 240 | 240 | 1 | 6 | ND(460-600) | | 880 | |
| | MW | ND(10-20) | NA | NA | 0 | 5 | ND(10) | 0.2 | 0.0092 | |
| | RES | ND(5.0) | NA | NA | 0 | 5 | NA | 0.2 | 0.0092 | |
| Benzo(b)fluoranthene | SS | 230 | 230 | 230 | 1 | 13 | ND(400) | | 8,800 | |
| | LS | ND(10-500) | NA | NA | 0 | 3 | NA | NA | 9.2 | |
| | LT | ND(200-1200) | NA | NA | 0 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | 9.2 | |
| | SD | 49 | 49 | 49 | 1 | 6 | ND(460-600) | | 88,000,000 | |
| | MW | ND(10-20) | NA | NA | 0 | 5 | ND(10) | | 0.92 | |
| | RES | ND(5.0) | NA | NA | 0 | 5 | NA | | 0.92 | |
| Chrysene | SS | 78 | 110 | 94 | 2 | 13 | ND(400) | | 87,000 | |
| | LS | ND(10-500) | NA | NA | 0 | 3 | NA | NA | 92 | |
| | LT | ND(200-1200) | NA | NA | 0 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | 92 | |
| | SD | ND(410-780) | NA | NA | 0 | 6 | ND(460-600) | | 870,000 | |
| | MW | ND(10-20) | NA | NA | 0 | 5 | ND(10) | | 9.2 | |
| | RES | ND(5.0) | NA | NA | 0 | 5 | NA | | 9.2 | |
| Di-n-butylphthalate | SS | ND(380-610) | NA | NA | 0 | 13 | ND(400) | | 780,000 | |
| | LS | ND(10-500) | NA | NA | 0 | 3 | NA | NA | 3,700 | |
| | LT | ND(200-1200) | NA | NA | 0 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | 3,700 | |
| | SD | ND(410-780) | NA | NA | 0 | 6 | 218.5 | | 7,800,000 | |
| | MW | ND(10-20) | NA | NA | 0 | 5 | ND(10) | | 370 | |
| | RES | ND(5.0) | NA | NA | 0 | 5 | NA | | 370 | |
| Di-n-octylphthalate | SS | ND(380-610) | NA | NA | 0 | 13 | ND(400) | | 160,000 | |
| | LS | ND(10-500) | NA | NA | 0 | 3 | NA | NA | 730 | |
| | LT | ND(200-1200) | NA | NA | 0 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | 730 | |
| | SD | 50 | 50 | 50 | 1 | 6 | ND(460-600) | | 1,600,000 | |
| | MW | ND(10-20) | NA | NA | 0 | 5 | ND(10) | | 73 | |
| | RES | ND(5.0) | NA | NA | 0 | 5 | NA | | 73 | |
| Diethylphthalate | SS | ND(380-610) | NA | NA | 0 | 13 | ND(400) | | 6,300,000 | |
| | LS | 29 | 110 | 70 | 2 | 3 | NA | NA | 29,000 | |
| | LT | 46 | 130 | 88 | 2 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | 29,000 | |
| | SD | ND(410-780) | NA | NA | 0 | 6 | ND(460-600) | | 63,000,000 | |
| | MW | ND(10-20) | NA | NA | 0 | 5 | ND(10) | | 2,900 | |
| | RES | ND(5.0) | NA | NA | 0 | 5 | NA | | 2,900 | |

Table 1 (continued)
Occurrence and Distribution of Contaminants
Bell Landfill Site
Towanda, Pennsylvania

| Parameter | Media (1) | Minimum (2) | Maximum (2) | Average (3) | Detects (4) | Samples (5) | Background (6) | MCL (7) (ug/L) | 1E-6 / HQ 0.1 Risk Level (8) | COC |
|---|---|---|---|---|---|---|---|---|---|---|
| Fluoranthene | SS | 51 | 73 | 62 | 2 | 13 | ND(400) | | 310,000 | |
| | LS | ND(10-500) | NA | NA | 0 | 3 | NA | NA | 1,500 | |
| | LT | ND(200-1200) | NA | NA | 0 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | 1,500 | |
| | SD | 47 | 47 | 47 | 1 | 6 | 88 | | 3,100,000 | |
| | MW | ND(10-20) | NA | NA | 0 | 5 | ND(10) | | 150 | |
| | RES | ND(5.0) | NA | NA | 0 | 5 | NA | | 150 | |
| Fluorene | SS | 54 | 54 | 54 | 1 | 13 | ND(400) | | 310,000 | |
| | LS | ND(10-500) | NA | NA | 0 | 3 | NA | NA | 1,500 | |
| | LT | ND(200-1200) | NA | NA | 0 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | 1,500 | |
| | SD | ND(410-780) | NA | NA | 0 | 6 | ND(460-600) | | 3,100,000 | |
| | MW | ND(10-20) | NA | NA | 0 | 5 | ND(10) | | 150 | |
| | RES | ND(5.0) | NA | NA | 0 | 5 | NA | | 150 | |
| N-Nitrosodiphenylamine | SS | 54 | 54 | 54 | 1 | 13 | ND(400) | | 130,000 | |
| | LS | ND(10-500) | NA | NA | 0 | 3 | NA | NA | 140 | |
| | LT | ND(200-1200) | NA | NA | 0 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | 140 | |
| | SD | ND(410-780) | NA | NA | 0 | 6 | ND(460-600) | | 1,300,000 | |
| | MW | ND(10-20) | NA | NA | 0 | 5 | ND(10) | | 14 | |
| | RES | ND(5.0) | NA | NA | 0 | 5 | NA | | 14 | |
| Naphthalene | SS | 60 | 270 | 170 | 3 | 13 | ND(400) | | 310,000 | |
| | LS | 14 | 14 | 14 | 1 | 3 | NA | NA | 1,500 | |
| | LT | ND(200-1200) | NA | NA | 0 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | 1,500 | |
| | SD | ND(410-780) | NA | NA | 0 | 6 | ND(460-600) | | 3,100,000 | |
| | MW | ND(10-20) | NA | NA | 0 | 5 | ND(10) | | 150 | |
| | RES | ND(5.0) | NA | NA | 0 | 5 | NA | | 150 | |
| Phenanthrene | SS | 56 | 210 | 133 | 2 | 13 | ND(400) | | 310,000 | |
| | LS | ND(10-500) | NA | NA | 0 | 3 | NA | NA | 1,500 | |
| | LT | ND(200-1200) | NA | NA | 0 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | 1,500 | |
| | SD | ND(410-780) | NA | NA | 0 | 6 | ND(460-600) | | 3,100,000 | |
| | MW | ND(10-20) | NA | NA | 0 | 5 | ND(10) | | 150 | |
| | RES | ND(5.0) | NA | NA | 0 | 5 | NA | | 150 | |
| Phenol | SS | 160 | 250 | 190 | 3 | 13 | ND(400) | | 4,700,000 | |
| | LS | 1100 | 3200 | 2150 | 2 | 3 | NA | NA | 22,000 | |
| | LT | 960 | 2600 | 1780 | 2 | 2 | NA | | NA | |
| | SW | ND(10) | NA | NA | 0 | 6 | ND(10) | | 22,000 | |
| | SD | ND(410-780) | NA | NA | 0 | 6 | ND(460-600) | | 47,000,000 | |
| | MW | ND(10-20) | NA | NA | 0 | 5 | ND(10) | | 2,200 | |
| | RES | ND(5.0) | NA | NA | 0 | 5 | NA | | 2,200 | |
| Pyrene | SS | 81 | 110 | 96 | 2 | 13 | ND(400) | | 230,000 | |
| | LS | ND(10-500) | NA | NA | 0 | 3 | NA | NA | 1,100 | |
| | LT | ND(200-1200) | NA | NA | 0 | 2 | NA | | NA | |
| | SW | ND(10) | NA | [illegible] | 0 | 6 | ND(10) | | 1,100 | |
| | SD | 66 | 66 | 66 | 1 | [illegible] | | | | |
| | MW | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | [illegible] | |

Table (continued)
Occurrence and Distribution of Contaminants
Bell Landfill Site
Towanda, Pennsylvania

| Parameter | Media (1) | Minimum (2) | Maximum (2) | Average (3) | Detects (4) | Samples (5) | Background (6) | MCL (7) (ug/L) | 1E-6 / HQ 0.1 Risk Level (8) | COC |
|---|---|---|---|---|---|---|---|---|---|---|
| bis(2-Ethylhexyl)phthalate | SS | ND(410) | NA | NA | 0 | 1 | ND(400) | | 46,000 | |
| | LS | 1 | 1 | 1 | 1 | 3 | NA | | 48 | |
| | LT | ND(200-1200) | NA | NA | 0 | 2 | NA | | NA | |
| | SW | 1 | 1 | 1 | 1 | 6 | ND(10) | | 48 | |
| | SD | ND(410-780) | NA | NA | 0 | 6 | ND(460-600) | | 460,000 | |
| | MW | ND(10-20) | NA | NA | 0 | 5 | ND(10) | 6 | 4.8 | |
| | RES | 21 | 21 | 21 | 1 | 5 | NA | 6 | 4.8 | Yes |

Footnotes:

(1) SS is surface soil. LS is leachate seep. LT is leachate tank. SW is surface water. SD is sediment. MW is monitoring well; the results reported are from filtered samples. RES is Residents' private wells.

(2) Minimum / maximum detected concentration above the sample quantitation limit (SQL). Units are: mg/kg for inorganic soil samples; ug/kg for organic soil samples; and ug/L for inorganic and organic water samples. Inorganic monitoring well results are reported as total (unfiltered) metals.

(3) Arithmetic average of constituent detections above the SQL.

(4) Number of times constituent was detected above the SQL. Sample results from duplicates were consolidated into a single sample result, using the higher detected concentration for each constituent.

(5) Number of samples taken and analyzed for the constituent. Sample number varies based on number of usable results (invalid results were not counted).

(6) Background samples are: surface soil, BGSS-1; surface water, the mean of SW-1 and SW-4; sediment, the mean of SD-1 and SD-4; monitoring wells, MW-1. No backgrour for leachate seeps, leachate tanks, or residential wells.

(7) Maximum Contaminant Level (federal drinking water standard) in ug/L.

(8) U.S. EPA, 1993. "Risk-Based Concentration Table, Fourth Quarter 1993," Roy L Smith, PhD, EPA Region III Senior Toxicologist, October 15. Units are ug/L for organic and inorganic water, ug/kg for organic soil and mg/kg for inorganic soil.

COC Contaminant of Concern
MCLG Maximum Contaminant Level Goal
TT Treatment Technique
NA Not applicable
ND( ) Not detected. The number (or range) is the SQL.
B Result is qualitatively invalid since this analyte was detected in a blank at a similar concentration.
* February 23, 1993 results
** Included per Region III guidance

Contaminants of concern (COCs) were selected from this list of positively identified chemicals in accordance with EPA Region III Technical Guidance. Region III EPA has developed risk-based concentrations for nearly 600 chemicals by combining toxicity values derived from IRIS, HEAST, OHEA and other EPA sources with "standard" exposure scenarios (EPA 1993a). In cases where a scenario does not apply (i.e., exposure to leachate), professional judgment was applied to determine levels of potential concern (Ioven 1993b).

The detection limits for several compounds were higher than risk-based concentrations and higher than Maximum Contaminant Levels (MCLs). Because the detection limits were higher than the evaluation criteria, these compounds could not be considered in the selection of COCs. Even though these compounds were not evaluated in the risk assessment, it should be noted that if they occur in environmental media, they may present a human health concern. The following table lists the compounds where detection limits were higher than evaluation criteria in groundwater.

Parameters with Health-Based Levels Less Than SQLs
Bell Landfill Site
Towanda, Pennsylvania

## MONITORING WELLS

Antimony *
Cadmium
Thallium *
1,1,2,2-Tetrachloroethane
1,1,2-Trichloroethane
Thallium
1,2-Dichloroethane
1,2-Dichloropropane
Benzene
Bromodichloromethane
Bromoform
Carbon Disulfide
Carbon Tetrachloride
Chlorobenzene
Chloroform
Chloromethane
Dibromochloromethane
Methylene Chloride
Tetrachloroethene
Trichloroethene
Vinyl Chloride *
cis-1,3-Dichloropropene
trans-1,3-Dichloropropene
Aldrin
Aroclor-1016
Aroclor-1221 *
Aroclor-1232
Aroclor-1242
Aroclor-1248
Aroclor-1254
Aroclor-1260
Dieldrin
Heptachlor
Heptachlor epoxide
Toxaphene
alpha-BHC
1,2,4-Trichlorobenzene
1,4-Dichlorobenzene
2,4-Dinitrophenol
2,6-Dinitrotoluene
2-Nitroaniline
3,3'-Dichlorobenzidine
3-Nitroaniline
4-Nitroaniline
Benzo(a)anthracene
Benzo(a)pyrene *
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Carbazole
Dibenz(a,h)anthracene
Hexachlorobenzene *
Hexachlorobutadiene
Hexachlorocyclopentadiene
Hexachloroethane
Indeno(1,2,3-cd)pyrene
N-Nitroso-di-n-propylamine
Nitrobenzene
Pentachlorophenol
bis(2-Chloroethyl)ether
bis(2-Ethylhexyl)phthalate *

## RESIDENTIAL WELLS [1]

Antimony *
Arsenic
Beryllium
Cadmium
Thallium
1,1,2,2-Tetrachloroethane
1,1,2-Trichloroethane
1,1-Dichloroethene
1,2-Dibromo-3-Chloropropane *
1,2-Dibromoethane
1,2-Dichloroethane
1,3-Dichlorobenzene
1,4-Dichlorobenzene
Benzene
Bromochloromethane
Bromodichloromethane
Carbon Tetrachloride
Chloroform
Dibromochloromethane
Vinyl Chloride
cis-1,3-Dichloropropene
trans-1,3-Dichloropropene
2,4-Dinitrophenol
2-Nitroaniline
3,3'-Dichlorobenzidine
Benzo(a)anthracene
Benzo(a)pyrene *
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Dibenz(a,h)anthracene
Hexachlorobenzene *
Hexachlorobutadiene
Hexachlorocyclopentadiene
Hexachloroethane
Indeno(1,2,3-cd)pyrene
N-Nitroso-di-n-propylamine
Nitrobenzene
Pentachlorophenol *
bis(2-Chloroethyl)ether

Source of Risk-Based Levels:

"Risk-Based Concentration Table, Fourth Quarter 1993," Roy L Smith, PhD, EPA Region III Senior Toxicologist, October 15.

[1] Residential wells were not analyzed for pesticides and PCBs.

SQL Sample Quantitation Limit
MCL Maximum Contaminant Level
* SQL exceeded MCL

Leachate - The COCs for leachate were selected if they exceeded the health-based levels for exposure to tap water by at least one order of magnitude. Based on this criterion, the following parameters were selected as COCs for leachate:

arsenic
cadmium
cobalt
chromium
manganese
molybdenum
1,2-dichloroethene
acetone
benzene
methylene chloride
trichloroethene
vinyl chloride
heptachlor epoxide
4-methylphenol
heptachlor epoxide
delta-BHC

Surface soil - The following contaminants exceeded health-based levels (direct contact, residential), per Region III Technical Guidance:

arsenic
barium
beryllium
cadmium
chromium
lead
manganese
mercury
benzo(a)pyrene

Groundwater - Monitoring Wells - The following contaminants exceeded health-based levels (tap water, residential), per Region III Technical Guidance:

aluminum
arsenic
barium
beryllium
chromium

copper
lead
manganese
nickel
vanadium
1,2-dichloroethene
benzene
tetrachloroethene
trichloroethene
vinyl chloride

Groundwater - Residential Wells - The following contaminants exceeded health-based levels (tap water, residential), per Region III Technical Guidance:

| | |
|---|---|
| Resident A | manganese |
| Resident C | bis(2-ethylhexyl)phthalate<br>arsenic |
| Resident D | arsenic |
| Resident F | manganese |

Surface Water - Region III Technical guidance does not address selecting COCs in surface water. Therefore, the following criteria were applied to select COCs: If health-based levels for exposure to tap water were exceeded by at least one order of magnitude, then the surface water constituents were selected as COCs. The only contaminant that exceeded these criteria is presented below:

manganese

Sediment - Region III Technical Guidance does not address selecting COCs in sediment. Therefore, the following criteria were applied for accomplishing this task: If health-based levels for exposure to soil under a residential scenario were exceeded by at least one order of magnitude, then sediment constituents were selected as COCs. The only contaminant that

**Table 2**
**Contaminants of Concern**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Leachate | Surface Soil | Groundwater (Monitoring Wells) | Groundwater (Residential Wells) | Surface Water | Sediment |
|---|---|---|---|---|---|
| Arsenic | Arsenic | Aluminum | Arsenic | Manganese | Manganese |
| Cadmium | Barium | Arsenic | Manganese | | |
| Cobalt | Beryllium | Barium | bis(2-ethylhexyl)phthalate | | |
| Chromium | Cadmium | Beryllium | | | |
| Manganese | Chromium | Chromium | | | |
| Molbydenum | Lead | Copper | | | |
| 1,2-Dichloroethene | Manganese | Lead | | | |
| Acetone | Mercury | Manganese | | | |
| Benzene | Benzo(a)pyrene | Nickel | | | |
| Methylene Chloride | | Vanadium | | | |
| Toluene | | 1,2-Dichloroethene | | | |
| Trichloroethene | | Benzene | | | |
| Vinyl Chloride | | Tetrachloroethene | | | |
| Heptachlor Epoxide | | Trichloroethene | | | |
| 4-Methylphenol | | Vinyl Chloride | | | |
| delta-BHC | | | | | |

# 3.0 EXPOSURE ASSESSMENT

Exposure assessment is conducted to identify pathways whereby human receptors may be exposed to Site contaminants and to estimate the frequency, duration,and magnitude of such exposures. Exposure assessment involves (1) characterization of the exposure setting; (2) identification of complete pathways of exposure; and (3) quantification of exposure. The exposure setting is discussed in the Remedial Investigation report being prepared separately by consultants to the potentially responsible parties (PRPs). The remaining elements of the exposure assessment are discussed in this section.

## 3.1 IDENTIFICATION OF EXPOSURE PATHWAYS

Exposure routes evaluated in the risk assessment are:

- Inadvertent ingestion of leachate
- Dermal absorption of leachate
- Inadvertent ingestion of soil
- Inhalation of dust
- Ingestion of groundwater
- Dermal absorption of groundwater
- Inhalation of vapors evolved from groundwater
- Inadvertent ingestion of surface water
- Dermal absorption of surface water
- Inadvertent ingestion of sediment
- Dermal absorption of sediment (Ioven 1993b).

### 3.1.1 Current Use

Current exposure pathways were evaluated according to the existing land use in the site vicinity. Current receptors include child trespassers, adult hunters, and residents in the area who use private wells. Exposure assumptions used to calculate risks for these receptors are outlined below.

Inadvertent Ingestion of Leachate - Child Trespasser - Leachate outbreaks may pool to such

an extent that a child trespasser or adult hunter may become exposed via incidental ingestion or dermal contact. Exposure assumptions used to calculate oral exposure to leachate were adapted from the method used to calculate ingestion of chemicals in surface water while swimming (EPA 1989a). To reflect the low likelihood that this exposure route is complete, the consumption rate of 50 ml/hr was halved. Exposure was considered from age 7 through age 16 for a total exposure period of 10 years. Exposure assumptions for the child trespasser scenario are:

1. Contact rate 25 ml/hr (conservative assumption)
2. Exposure time 2 hrs/event (conservative assumption)
3. Exposure frequency 26 days/yr, based on 1 day/week for 26 weeks (conservative assumption)
4. Exposure duration 10 years (estimated)
5. Body weight 37 kg (Harris 1993a)
6. Averaging time 70 years for cancer risk and 10 years for noncancer risk (EPA 1989a).

Inadvertent Ingestion of Leachate - Adult Hunter - Exposure assumptions for the adult hunter scenario are:

1. Contact rate 25 ml/hr (conservative assumption)
2. Exposure time 2 hrs/event (conservative assumption)
3. Exposure frequency 26 days/yr (conservative assumption)
4. Exposure duration 30 years (Harris 1993a and b)
5. Body weight 70 kg (EPA 1991b)
6. Averaging time 70 years for cancer risk and 30 years for noncancer risk (EPA 1989a).

Dermal Contact with Leachate - Child Trespasser - Exposure assumptions for the child trespasser scenario are:

1. Skin surface area available for contact 3,560 $cm^2$ (EPA 1985)
2. Exposure time 2 hrs/event (conservative assumption)
3. Exposure frequency 26 days/yr (conservative assumption)
4. Exposure duration 10 years (estimated)
5. Body weight 37 kg (Harris 1993a)
6. Averaging time 70 years for cancer risk and 10 years for noncancer risk (EPA 1989a).

Dermal Contact with Leachate - Adult Hunter - Exposure assumptions for the adult hunter scenario are:

1. Skin surface area available for contact 8,620 $cm^2$ (EPA 1989a)
2. Exposure time 2 hrs/event (conservative assumption)
3. Exposure frequency 26 days/yr (based on 1 day/week for 26 weeks, conservative assumption)
4. Exposure duration 30 years (Harris 1993a and b)
5. Body weight 70 kg (EPA 1991b)
6. Averaging time 70 years for cancer risk and 30 years for noncancer risk (EPA 1989a).

Inadvertent Ingestion of Soil - Child Trespasser - Exposure was considered from age 7 through age 16 for a total exposure period of 10 years. Exposure doses were based on the following assumptions:

1. Ingestion rate 100 mg/day (conservative assumption)
2. Fraction ingested from contaminated source 100 percent (conservative assumption)
3. Exposure frequency 26 days/year (estimated)
4. Exposure duration 10 years (estimated)
5. Body weight 37 kg (Harris 1993a)
6. Averaging time 70 years for cancer effects and 10 years for noncancer effects (EPA 1989a).

Inadvertent Ingestion of Soil - Adult Hunter - Exposure assumptions for the adult hunter scenario are:

1. Ingestion rate 50 mg/day (conservative assumption)
2. Fraction ingested from contaminated source 100 percent (conservative assumption)
3. Exposure frequency 26 days/year, based on 1 day/week for 26 weeks (conservative assumption)
4. Exposure duration 30 years (Harris 1993a and b)
5. Body weight 70 kg (EPA 1991b)
6. Averaging time 70 years for cancer effects and 30 years for noncancer effects (EPA 1989a).

Inhalation of Fugitive Dusts - Child Trespasser - Inhalation exposure to dusts may be estimated based on an equation which relates the contaminant concentration in soil with the respirable particulate concentration ($PM_{10}$) in the air from fugitive dust emissions (EPA 1991c). As a conservative approach, the default particulate emissions factor (PEF), which assumes no vegetative cover, was used. Exposure doses were based on the following

assumptions:

1. Exposure duration 10 years (estimated)
2. Exposure frequency 26 days/year, based on 1 day/week for 26 weeks (estimated)
3. Inhalation rate 20 $m^3$/day (estimated)
4. Body weight 37 kg (Harris 1993a)
5. Averaging time 70 years for cancer effects and 10 years for noncancer effects (EPA 1989a).

Inhalation of Fugitive Dusts - Adult Hunter - Exposure assumptions for the adult hunter scenario are:

1. Exposure duration 30 years (estimated)
2. Exposure frequency 26 days/year (estimated)
3. Inhalation rate 20 $m^3$/day (EPA 1991b)
4. Body weight 70 kg (EPA 1991b)
5. Averaging time 70 years for cancer effects and 30 years for noncancer effects (EPA 1989a).

Ingestion of Groundwater - Child Resident - Several private wells exist in the area. Exposure assumptions for a child are:

1. Ingestion rate 1 L/day (conservative estimate)
2. Exposure frequency 350 days/yr (EPA 1991b)
3. Exposure duration 6 years (EPA 1991b)
4. Body weight 15 kg (EPA 1991b)
5. Averaging time 70 years for cancer risk and 6 years for noncancer risk (EPA 1989a).

Ingestion of Groundwater - Adult Resident - Exposure assumptions for an adult resident are:

1. Ingestion rate 2 L/day (EPA 1991b)
2. Exposure frequency 350 days/yr (EPA 1991b)
3. Exposure duration 24 or 30 years (EPA 1991b, Harris 1993a)
4. Body weight 70 kg (EPA 1991b)
5. Averaging time 70 years for cancer risk and 24 or 30 years for noncancer risk (EPA 1989a).

Dermal Contact with Groundwater - Child Resident - Exposure assumptions for the child resident scenario are:

1. Skin surface area available for contact 7,200 $cm^2$ (Ioven 1993c)
2. Exposure time 0.33 hr/event (conservative assumption)
3. Exposure frequency 350 days/yr (conservative assumption)

4. Exposure duration 6 years (estimated)
5. Body weight 15 kg (EPA 1991b)
6. Averaging time 70 years for cancer risk and 6 years for noncancer risk (EPA 1989a).

Inadvertent Ingestion of Surface Water - Child Trespasser - Two perennial streams flow adjacent to or through the site. Exposure assumptions for the child trespasser scenario are:

1. Contact rate 50 ml/hr (EPA 1989a)
2. Exposure time 2 hrs/event (conservative assumption)
3. Exposure frequency 26 days/yr (conservative assumption)
4. Exposure duration 10 years (estimated)
5. Body weight 37 kg (Harris 1993a and b)
6. Averaging time 70 years for cancer risk and 10 years for noncancer risk (EPA 1989a).

Inadvertent Ingestion of Surface Water - Adult Hunter - Exposure assumptions for the adult hunter scenario are:

1. Contact rate 50 ml/hr
2. Exposure time 2 hrs/event (conservative assumption)
3. Exposure frequency 26 days/yr (conservative assumption)
4. Exposure duration 30 years (Harris 1993a and b)
5. Body weight 70 kg (EPA 1991b)
6. Averaging time 70 years for cancer risk and 30 years for noncancer risk (EPA 1989a).

Dermal Contact with Surface Water - Child Trespasser - Exposure assumptions for the child trespasser scenario are:

1. Skin surface area available for contact 3,560 $cm^2$ (EPA 1985)
2. Exposure time 2 hrs/event (conservative assumption)
3. Exposure frequency 26 days/yr (conservative assumption)
4. Exposure duration 10 years (estimated)
5. Body weight 37 kg (Harris 1993a)
6. Averaging time 70 years for cancer risk and 10 years for noncancer risk (EPA 1989a).

Dermal Contact With Surface Water - Adult Hunter - Exposure assumptions for the adult hunter scenario are:

1. Skin surface area available for contact 8,620 $cm^2$ (EPA 1989a)
2. Exposure time 2 hrs/event (conservative assumption)
3. Exposure frequency 26 days/yr (conservative assumption)
4. Exposure duration 30 years (Harris 1993a and b)
5. Body weight 70 kg (EPA 1991b)
6. Averaging time 70 years for cancer risk and 30 years for noncancer risk (EPA 1989a).

Inadvertent Ingestion of Sediment - Child Trespasser - Exposure was considered from age 7 through age 16 for a total exposure period of 10 years. Exposure doses were based on the following assumptions:

1. Ingestion rate 100 mg/day (conservative assumption)
2. Fraction ingested from contaminated source 100 percent (conservative assumption)
3. Exposure frequency 26 days/year (estimated)
4. Exposure duration 10 years (estimated)
5. Body weight 37 kg (Harris 1993a and b)
6. Averaging time 70 years for cancer effects and 10 years for noncancer effects (EPA 1989a).

Inadvertent Ingestion of Sediment - Adult Hunter - Exposure assumptions for the adult hunter scenario are:

1. Ingestion rate 50 mg/day (conservative assumption)
2. Fraction ingested from contaminated source 100 percent (conservative assumption)
3. Exposure frequency 26 days/year, based on 1 day/week for 26 weeks (conservative assumption)
4. Exposure duration 30 years (Harris 1993a and b)
5. Body weight 70 kg (EPA 1991b)
6. Averaging time 70 years for cancer effects and 30 years for noncancer effects (EPA 1989a).

Dermal Contact with Sediment - Child Trespasser - Exposure assumptions for the child trespasser scenario are:

1. Skin surface area available for contact 3,560 $cm^2$ (EPA 1985)
2. Adherence factor 1 $mg/cm^2$ hrs/event (conservative assumption)
3. Exposure frequency 26 days/yr (conservative assumption)
4. Exposure duration 10 years (estimated)
5. Body weight 37 kg (Harris 1993a and b)
6. Averaging time 70 years for cancer risk and 10 years for noncancer risk (EPA 1989a).

Dermal Contact with Sediment - Adult Hunter - Exposure assumptions for the adult hunter scenario are:

1. Skin surface area available for contact 8,620 $cm^2$ (EPA 1989a)
2. Adherence factor 1 $mg/cm^2$ hrs/event (conservative assumption)
3. Exposure frequency 26 days/yr (conservative assumption)
4. Exposure duration 30 years (Harris 1993a and b)
5. Body weight 70 kg (EPA 1991b)
6. Averaging time 70 years for cancer risk and 30 years for noncancer risk (EPA 1989a).

3.1.2 Future Use

Future use exposure pathways were evaluated by considering changes in land use such that the site is developed for residential or commercial use. Potential receptors include child and adult residents and adult workers. Exposure assumptions for the future use scenario are outlined below.

Inadvertent Ingestion of Leachate - Child Resident - Exposure assumptions for the child resident scenario are:

1. Contact rate 25 ml/hr (conservative assumption)
2. Exposure time 2 hrs/event (conservative assumption)
3. Exposure frequency 104 days/yr (conservative assumption based on 4 days/week for 26 weeks)
4. Exposure duration 6 years (EPA 1991b)
5. Body weight 15 kg (EPA 1991b)
6. Averaging time 70 years for cancer risk and 6 years for noncancer risk (EPA 1989a).

Dermal Contact with Leachate - Child Resident - Exposure assumptions for the child resident scenario are:

1. Skin surface area available for contact 1,860 $cm^2$ (EPA 1985)
2. Exposure time 2 hrs/event (conservative assumption)
3. Exposure frequency 104 days/yr (conservative assumption)
4. Exposure duration 6 years (EPA 1991b)
5. Body weight 15 kg (EPA 1991b)

6. Averaging time 70 years for cancer risk and 6 years for noncancer risk (EPA 1989a).

Inadvertent Ingestion of Soil - Child Resident - Exposure was considered from birth through age 5 for a total exposure period of 6 years. Exposure doses were based on the following assumptions:

1. Ingestion rate 200 mg/day (EPA 1991b)
2. Fraction ingested from contaminated source 100 percent (conservative assumption)
3. Exposure frequency 350 days/year (EPA 1991b)
4. Exposure duration 6 years (EPA 1991b)
5. Body weight 15 kg (EPA 1991b)
6. Averaging time 70 years for cancer effects and 6 years for noncancer effects (EPA 1989a).

Inadvertent Ingestion of Soil - Adult Worker Exposure assumptions for the adult worker scenario are:

1. Ingestion rate 50 mg/day (EPA 1991b)
2. Fraction ingested from contaminated source 100 percent (conservative assumption)
3. Exposure frequency 250 days/year (EPA 1991b)
4. Exposure duration 25 years (EPA 1991b)
5. Body weight 70 kg (EPA 1991b)
6. Averaging time 70 years for cancer effects and 25 years for noncancer effects (EPA 1989a)

Inhalation of Fugitive Dusts - Child Resident - Exposure assumptions for the child resident scenario are:

1. Exposure duration 6 years (estimated)
2. Exposure frequency 350 days/year (estimated)
3. Inhalation rate 20 $m^3$/day (conservative estimate)
4. Body weight 15 kg (EPA 1991b)
5. Averaging time 70 years for cancer effects and 6 years for noncancer effects (EPA 1989a).

Inhalation of Fugitive Dusts - Adult Worker - Exposure assumptions for the adult worker scenario are:

1. Exposure duration 25 years (EPA 1991b)
2. Exposure frequency 250 days/year (EPA 1991b)

3. Inhalation rate 20 $m^3$/day (EPA 1991b)
4. Body weight 70 kg (EPA 1991b)
5. Averaging time 70 years for cancer effects and 25 years for noncancer effects (EPA 1989b).

Ingestion of Groundwater - Child Resident - Groundwater may be developed at the site within the existing contaminant plume. Exposure assumptions for a child in the future use scenario are:

1. Ingestion rate 1 L/day (conservative estimate)
2. Exposure frequency 350 days/yr (EPA 1991b)
3. Exposure duration 6 years (EPA 1991b)
4. Body weight 15 kg (EPA 1991b)
5. Averaging time 70 years for cancer risk and 6 years for noncancer risk (EPA 1989a).

Ingestion of Groundwater - Adult Resident - Exposure assumptions for an adult in the future use scenario are:

1. Ingestion rate 2 L/day (EPA 1991b)
2. Exposure frequency 350 days/yr (EPA 1991b)
3. Exposure duration 24 or 30 years (EPA 1991b)
4. Body weight 70 kg (EPA 1991b)
5. Averaging time 70 years for cancer risk and 24 years for noncancer risk (EPA 1989a).

Ingestion of Groundwater - Adult Worker - Exposure assumptions for an adult worker in the future use scenario are:

1. Ingestion rate 1 L/day (EPA 1991b)
2. Exposure frequency 250 days/yr (EPA 1991b)
3. Exposure duration 25 years (EPA 1991b)
4. Body weight 70 kg (EPA 1991b)
5. Averaging time 70 years for cancer risk and 25 years for noncancer risk (EPA 1989a).

Inhalation of Volatiles - Exposure to volatile organic compounds (VOCs) released from water while showering was modeled according to the method described by Foster and Chrostowski, 1987. Input parameters used in the model were the same as those used by the authors with the following exceptions: 12 minute shower (total time in bathroom 20 minutes); air exchange rate 1 $hr^{-1}$; and inhalation rate of 20 $m^3$/day (Ioven 1993d). Three scenarios were

modeled: 24-yr and 30-yr adult resident and adult worker. Exposure durations were 24 or 30 years for the adult residents, and 25 years for the adult worker.

Inadvertent Ingestion of Surface Water - Child Resident - Exposure assumptions for the child resident scenario are:

1. Contact rate 50 ml/hr (EPA 1989a)
2. Exposure time 2 hrs/event (conservative assumption)
3. Exposure frequency 104 days/yr (conservative assumption)
4. Exposure duration 6 years (EPA 1991b)
5. Body weight 15 kg (EPA 1991b)
6. Averaging time 70 years for cancer risk and 6 years for noncancer risk (EPA 1989a).

Dermal Contact with Surface Water - Child Resident - Exposure assumptions for the child resident scenario are:

1. Skin surface area available for contact 1,860 $cm^2$ (EPA 1985)
2. Exposure time 2 hrs/event (conservative assumption)
3. Exposure frequency 104 days/yr (conservative assumption)
4. Exposure duration 6 years (EPA 1991b)
5. Body weight 15 kg (EPA 1991b)
6. Averaging time 70 years for cancer risk and 6 years for noncancer risk (EPA 1989a).

Inadvertent Ingestion of Sediment - Child Resident - Exposure was considered from age 0 through age 6 for a total exposure period of 6 years. Exposure doses were based on the following assumptions:

1. Ingestion rate 100 mg/day (conservative assumption)
2. Fraction ingested from contaminated source 100 percent (conservative assumption)
3. Exposure frequency 104 days/year (estimated)
4. Exposure duration 6 years (estimated)
5. Body weight 15 kg (EPA 1991b)
6. Averaging time 70 years for cancer effects and 10 years for noncancer effects (EPA 1989a).

Dermal Contact with Sediment - Child Resident - Exposure assumptions for the child trespasser scenario are:

1. Skin surface area available for contact 1,860 $cm^2$ (EPA 1985)
2. Adherence factor 1 $mg/cm^2$ hrs/event (conservative assumption)
3. Exposure frequency 104 days/yr (conservative assumption)
4. Exposure duration 6 years (estimated)
5. Body weight 15 kg (EPA 1991b)
6. Averaging time 70 years for cancer risk and 6 years for noncancer risk (EPA 1989a).

## 3.2 QUANTIFICATION OF EXPOSURE

Reasonable maximum exposure (RME) point concentrations were calculated for leachate, surface soil, groundwater, and surface water using the lesser of the 95 percent upper confidence limit (UCL) on the arithmetic average for a lognormal distribution or the maximum detected value (EPA 1991d). Where a COC was detected one or more times within a particular medium, one-half the sample quantitation limit was used as a proxy concentration for non-detects in the remaining samples. RME concentrations are presented in **Tables 3** through **7**. An example calculation is presented in **Table 8**.

The following samples were combined to calculate RMEs: leachate seeps, US-1, LS-1, MD-1 (leachate tank results were not used to calculate RMEs); groundwater, MW-2, -3, -5, and -6 for inorganics and MW-3 and -6 for organics; surface soil, USSS-1, USSS-2, UTSS-1, UTSS-2, LTSS-1, LSSS-1, LTSS-2, LSSS-2, MPSD-1, DPSS-1, DPSS-2, DASS-1, DASS-2; surface water, SW-2, -3, -5, -6, -7, -8; sediment, SD-2, -3, -5, -6, -7, -8. The results from the private well samples were considered individually and were not combined into a single RME. The results for the COCs detected in residential wells are presented in **Table 9**.

## 3.3 UNCERTAINTIES OF EXPOSURE ASSESSMENT

The exposure scenarios presented in Section 3.1 contribute a considerable degree of uncertainty to the risk assessment. Actual exposure frequencies are unknown; estimates are

**Table 3**
**Reasonable Maximum Exposure Concentrations for Contaminants of Concern in Leachate Seeps**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | Mean of Transformed Data | Standard Deviation of Data | H (Statistic from Table) | Sample Size (1) | UCL (ug/L) | Minimum (ug/L) | Maximum (ug/L) | RME (ug/L) |
|---|---|---|---|---|---|---|---|---|
| Arsenic | 2.60 | 0.73 | 9.12 | 3 | 2E+03 | 5.9 | 23.1 | 23.1 |
| Cadmium | 2.59 | 2.28 | 32.69 | 3 | 1E+25 | 2 | 166 | 166 |
| Chromium | 4.19 | 1.29 | 16.33 | 3 | 4E+08 | 17.4 | 227 | 227 |
| Cobalt | 5.23 | 2.34 | 26.14 | 3 | 2E+22 | 14.6 | 1440 | 1440 |
| Manganese | 10.47 | 1.57 | 19.60 | 3 | 3E+14 | 5880 | 108000 | 108000 |
| Molybdenum | 7.48 | 0.02 | 2.75 | 2 | 2E+03 | 1750 | 1800 | 1800 |
| 1,2–Dichloroethene (total) | 5.04 | 2.99 | 39.23 | 3 | 2E+40 | 5 | 590 | 590 |
| Acetone | 6.11 | 3.91 | 52.31 | 3 | 5E+68 | 5 | 5400 | 5400 |
| Benzene | 3.77 | 2.95 | 39.23 | 3 | 1E+39 | 5 | 13 | 13 |
| Methylene Chloride | 6.07 | 4.32 | 58.85 | 3 | 7E+84 | 5 | 28000 | 28000 |
| Toluene | 5.85 | 1.66 | 22.87 | 3 | 7E+14 | 51 | 920 | 920 |
| Trichloroethene | 4.43 | 2.44 | 32.69 | 3 | 6E+27 | 5 | 350 | 350 |
| Vinyl Chloride | 4.17 | 2.78 | 39.23 | 3 | 1E+37 | 5 | 44 | 44 |
| Heptachlor epoxide | –2.98 | 1.38 | 19.60 | 3 | 3E+07 | 0.021 | 0.021 | 0.021 |
| 4–Methylphenol | 5.72 | 3.59 | 45.77 | 3 | 6E+55 | 5 | 3800 | 3800 |
| delta–BHC | –1.30 | 2.65 | 32.69 | 3 | 4E+27 | 0.025 | 4.7 | 4.7 |

(1) Sample size based on number of usable results. Invalid results were not counted.

UCL Upper Confidence Limit

SQL Sample Quantitation Limit

Minimum: The lowest detected concentration or 1/2 the SQL (may differ from Table 1 which shows the range of detects)

Maximum: The highest detected concentration.

RME, Reasonable Maximum Exposure (UCL or maximum when UCL is greater than maximum)

NA Not Applicable

**Table 4**
**Reasonable Maximum Exposure Concentrations for Contaminants of Concern in Surface Soil**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | Mean of Transformed Data | Standard Deviation of Data | H (Statistic from Table) | Sample Size (1) | UCL (mg/kg) | Minimum (mg/kg) | Maximum (mg/kg) | RME (mg/kg) |
|---|---|---|---|---|---|---|---|---|
| Arsenic | 1.70 | 0.70 | 2.414 | 13 | 11.4 | 2 | 25.3 | 11.4 |
| Barium | 5.11 | 0.72 | 2.414 | 13 | 354 | 83.9 | 1320 | 354 |
| Beryllium | −0.93 | 0.42 | 2.026 | 13 | 0.55 | 0.12 | 0.64 | 0.55 |
| Cadmium | 1.81 | 2.36 | 6.067 | 10 | 11663 | 0.12 | 134 | 134 |
| Chromium | 3.20 | 0.28 | 1.927 | 13 | 30 | 15.9 | 39.1 | 30 |
| Lead | 3.54 | 1.90 | 4.962 | 13 | 3166 | 9.4 | 7840 | 3166 |
| Manganese | 7.46 | 1.42 | 3.896 | 13 | 23655 | 36.5 | 10100 | 10100 |
| Mercury | −2.18 | 1.23 | 3.389 | 13 | 1 | 0.035 | 2.4 | 1 |
| Benzo(a)pyrene | NA | NA | NA | 1 | 0.12 | 0.12 | 0.12 | 0.12 |

(1) Sample size is based on number of usable results. Invalid results are not counted.

UCL Upper Confidence Limit

SQL Sample Quantitation Limit

Minimum: The lowest detected concentration or 1/2 the SQL (may differ from Table 1 which shows the range of detects)

Maximum: The highest detected concentration.

RME Reasonable Maximum Exposure (UCL or maximum when UCL is greater than maximum)

NA Not Applicable

RME for benzo(a)pyrene based on single positive detection.

**Table 5**
**Reasonable Maximum Exposure Concentrations for Contaminants of Concern in Groundwater**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | Mean of Transformed Data | Standard Deviation of Data | H (Statistic from Table) | Sample Size (1) | UCL (ug/L) | Minimum (ug/L) | Maximum (ug/L) | RME (ug/L) |
|---|---|---|---|---|---|---|---|---|
| Aluminum | 9.20 | 1.53 | 7.120 | 4 | 16840230 | 1330 | 32800 | 32800 |
| Arsenic | 1.86 | 1.80 | 8.250 | 4 | 176688 | 0.6 | 31.3 | 31.3 |
| Barium | 5.81 | 1.30 | 6.001 | 4 | 69697 | 53.3 | 908 | 908 |
| Berylium | -0.19 | 1.18 | 6.001 | 4 | 98 | 0.15 | 2.2 | 2.2 |
| Chromium | 3.42 | 1.27 | 6.001 | 4 | 5562 | 9.3 | 161 | 161 |
| Copper | 4.90 | 0.83 | 4.062 | 2 | 5489 | 74.6 | 241 | 241 |
| Lead | 1.69 | 2.39 | 11.670 | 4 | 906562858 | 0.25 | 50.6 | 50.6 |
| Manganese | 6.46 | 1.64 | 8.250 | 4 | 6010984 | 56.6 | 1950 | 1950 |
| Nickel | 3.16 | 1.48 | 7.120 | 4 | 30737 | 4.6 | 140 | 140 |
| Vanadium | 2.44 | 1.77 | 8.250 | 4 | 257154 | 1 | 45.8 | 45.8 |
| 1,2-Dichloroethene (total) | 2.43 | 0.19 | 3.295 | 2 | 21 | 10 | 13 | 13 |
| Benzene | NA | NA | NA | 1 | NA | 1 | 1 | 1 |
| Tetrachloroethene | 1.49 | 0.38 | 5.220 | 2 | 34 | 3.4 | 5.8 | 5.8 |
| Trichloroethene | 3.18 | 0.06 | 2.750 | 2 | 28 | 23 | 25 | 25 |
| Vinyl Chloride | 1.15 | 0.65 | 9.120 | 2 | 1437 | 2 | 5 | 5 |

(1) Sample size based on number of usable results. Invalid results are not counted.

Inorganics, monitoring wells 2, 3, 5, and 6

Organics, monitoring wells 3 and 6

UCL Upper Confidence Limit

SQL Sample Quantitation Limit

NA Not Applicable

Minimum: The lowest detected concentration or 1/2 the SQL (may differ from Table 1 which shows the range of detects)

Maximum: The highest detected concentration.

RME Reasonable Maximum Exposure (UCL or maximum when UCL is greater than maximum)

Benzene results from 11/5/92 sampling. Other VOCs from 2/23/93 sampling.

**Table 6**
**Reasonable Maximum Exposure Concentrations for Contaminants of Concern in Surface Water**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | Mean of Transformed Data | Standard Deviation of Data | H (Statistic from Table) | Sample Size | UCL (ug/L) | Minimum (ug/L) | Maximum (ug/L) | RME (ug/L) |
|---|---|---|---|---|---|---|---|---|
| Manganese | 3.41 | 2.50 | 8.339 | 6 | 7843587 | 2.6 | 796 | 796 |

UCL Upper Confidence Limit

SQL Sample Quantitation Limit

Minimum: The lowest detected concentration or 1/2 the SQL (may differ from Table 1 which shows the range of detects)

Maximum: The highest detected concentration.

RME Reasonable Maximum Exposure (UCL or maximum when UCL is greater than maximum)

**Table 7**
**Reasonable Maximum Exposure Concentrations for Contaminants of Concern in Sediment**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | Mean of Transformed Data | Standard Deviation of Data | H (Statistic from Table) | Sample Size | UCL (mg/kg) | Minimum (mg/kg) | Maximum (mg/kg) | RME (mg/kg) |
|---|---|---|---|---|---|---|---|---|
| Manganese | 7.15 | 0.72 | 2.904 | 6 | 4236 | 587 | 3620 | 3620 |

UCL Upper Confidence Limit

SQL Sample Quantitation Limit

Minimum: The lowest detected concentration or 1/2 the SQL (may differ from Table 1 which shows the range of detects)

Maximum: The highest detected concentration.

RME Reasonable Maximum Exposure (UCL or maximum when UCL is greater than maximum)

**Table 8**
**Equation and Example Calculation for**
**Reasonable Maximum Exposure Concentrations**
**Bell Landfill Site**
**Towanda, Pennsylvania**

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Equation Definition:

$$UCL = e^{\left(\bar{x} + 0.5s^2 + \frac{sH}{\sqrt{n-1}}\right)}$$

where:

| | | |
|---|---|---|
| UCL | = | upper confidence limit |
| e | = | constant (base of the natural log, equal to 2.718) |
| $\bar{x}$ | = | mean of the transformed data |
| s | = | standard deviation of the transformed data |
| H | = | H-statistic (e.g., from table published in Gilbert) |
| n | = | number of samples |

Example Calculation (arsenic in surface soil)

$$UCL = e^{(1.70 + 0.5(0.70)^2 + 0.70(2.414)/\sqrt{13-1})}$$

$$UCL = 11.4 mg/kg$$

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Source: Supplemental Guidance to RAGS: Calculating the Concentration Term, OSWER Publication 9285.7-08, May 1992.

**Table 9**
**Contaminant Summary Residential Wells**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Residential Wells | bis(2-Ethylhexyl)-phthalate | Arsenic | Manganese |
|---|---|---|---|
| Resident F | – | – | 54 |
| Resident E | – | – | – |
| Resident C | 21 | 1.2 | – |
| Resident D | – | 2.5 | – |
| Resident G (1) | – | 2.6 | – |
| Resident A | – | – | 31.2 |

Results are reported in ug/L for analytes which were detected.

– Not Detected

(1) – This sample is a blind duplicate of Resident D.

based on available guidance. Actual exposure is not expected to exceed the values presented but may be much lower.

Exposure point concentrations and subsequent doses were calculated based on the assumption that the current site conditions would remain stable throughout the exposure period. Natural attenuation processes that would reduce contaminant concentrations and the likelihood of exposure were not considered. The use of conservative assumptions in the exposure assessment is believed to result in an overestimate of risk. Actual site risk may be lower than the estimates presented here but is not likely to be greater.

Constituents which were reported as less than the SQL were listed as ND, Not Detected. Some of the SQLs are greater than risk-based concentration levels or drinking water standards. Therefore, there is some uncertainty associated with the quantification of risk, since some compounds may be present but the detection limit is too high to detect their presence. To minimize the liklihood of underestimating the risk posed by non-detected constituents, one-half the SQL was used as a proxy concentration for non-detects when the constituent was detected in another sample of the same media. In cases where one-half the SQL exceeded the maximum detected concentration, the maximum concentration value was used in the risk calculations. Thus, one-half the SQL was used only when the it was less than the maximum detected value.

The toxicity of delta-BHC (HCCH) was evaluated based on the toxicity values of lindane. Lindane was chosen as a surrogate because it is similar in chemical structure to delta-BHC. Therefore, risk estimate for delta-BHC may be higher or lower than presented since the toxicity value used is an alternate value.

# 4.0 TOXICITY ASSESSMENT

Toxicity assessment is a two-step process whereby the potential hazards associated with route-specific exposure to a given chemical are 1) identified by reviewing relevant human and animal studies; and 2) quantified through analysis of dose-response relationships. EPA has conducted numerous toxicity assessments that have undergone extensive review within the scientific community. EPA toxicity assessments and the resultant toxicity values will be used in the baseline evaluation to determine both carcinogenic and noncarcinogenic risks associated with each chemical of concern and route of exposure.

EPA toxicity values that are used in this assessment include:

- reference dose values (RfDs) for noncarcinogenic effects
- cancer slope factors (CSFs) for carcinogenic effects

Reference doses have been developed by EPA for indicating the potential for adverse health effects from exposure to chemicals exhibiting noncarcinogenic (systemic) effects. Reference doses are ideally based on studies where either animal or human populations were exposed to a given compound by a given route of exposure for the major portion of the life span (referred to as a chronic study). The RfD is derived by determining dose-specific effect levels from all the available quantitative studies, and applying uncertainty factors to the most appropriate effect level to determine an RfD for humans. The RfD represents a threshold for toxicity. RfDs are derived such that human lifetime exposure to a given chemical via a given route at a dose at or below the RfD should not result in adverse health effects, even for the most sensitive members of the population.

Cancer slope factors are route-specific values derived only for compounds that have been shown to cause an increased incidence of tumors in either human or animal studies. The slope factor is an upper bound estimate of the probability of a response per unit intake of a chemical over a lifetime and is determined by low-dose extrapolation from human or animal studies. When an animal study is used, the final slope factor has been adjusted to account

for extrapolation of animal data to humans. If the studies used to derive the slope factor were conducted for less than the life span of the test organism, the final slope factor has been adjusted to reflect risk associated with lifetime exposure.

The EPA RfDs and CSFs used in this assessment were obtained from EPA's Integrated Risk Information System (IRIS) database (EPA 1993b). Values that appear in IRIS have been extensively reviewed by EPA work groups and thus represent Agency consensus. If no values for a given compound and route of exposure were listed in IRIS, then EPA's Health Effects Assessment Summary Tables (HEAST) were consulted for values (EPA, 1993c). **Tables 10** and **11** summarize the toxicity values for carcinogenic and noncarcinogenic COCs, respectively. The toxicity information for noncarcinogenic and carcinogenic effects of the chemicals of concern are summarized in **Appendix A.**

The toxicity values used in this report are associated with significant uncertainty. Most health effects information has been developed using laboratory animals exposed to high doses. Although species differences in absorption, distribution, metabolizing excretion and target organ sensitivity are well documented, available data are not sufficient to allow compensation for these differences. Most laboratory studies strictly control as many factors as possible, yet the human population is genetically diverse and affected by a variety of diets, occupations and other factors. When human epidemiological data are available, a different set of uncertainties is presented. For instance, exposure dose is seldom well characterized in such studies. Additionally, while consideration of the weight-of-evidence is important to interpreting cancer assessments, calculations to characterize cancer risk do not distinguish between Class A, B, and C carcinogens.

There is also considerable uncertainty associated with the toxicity of mixtures. For the most part, data about the toxicity of mixtures are unavailable. Rather, toxicity studies are generally performed using a single chemical. Chemicals present in a mixture can interact chemically to yield a new chemical or one can act independently. The risk assessment assumes that toxicity is additive; cancer and noncancer risk were summed across chemicals.

**Table 10**
**Cancer Slope Factors, Tumor Sites and EPA Cancer Classifications**
**Contaminants of Concern**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | Cancer Slope Factor / Unit Risk | | | | Tumor Sites | | | EPA Class |
|---|---|---|---|---|---|---|---|---|
| | CSFo | Unit Risk (inhalation) | CSFi | CSFd | Oral | Inhalation | Dermal | |
| Acetone | NA | NA | NA | NA | NA | NA | NA | D |
| Aluminum | NA | NA | NA | NA | NA | NA | NA | D |
| Arsenic | 1.75E+00 (1) | 4.3E−03 (2) | 1.5E+01 (2) | 8.8E+00 (3) | Skin | Lung | NA | A |
| Barium | NA | NA | NA | NA | NA | NA | NA | D |
| Benzene | 2.9E−02 (2) | 8.3E−06 (2) | 2.9E−02 (2) | 3.6E−02 (3) | Leukemia | Leukemia | NA | A |
| Benzo(a)pyrene | 7.3E+00 (1) | NA | NA | 1.5E+01 (3) | Forestomach | NA | NA | B2 |
| Beryllium | 4.3E+00 (2) | 2.4E−03 (2) | 8.4E+00 (2) | 2.2E+01 (3) | All sites | Lung | NA | B2 |
| Bis(2−Ethylhexyl)phthalate | 1.4E−02 (2) | NA | NA | 2.8E−02 (3) | Liver | NA | NA | B2 |
| Cadmium | NA | 1.8E−03 (2) | 6.3E+00 (2) | NA | NA | Lung, trachea | NA | B1 |
| Chromium III | NA | NA | NA | NA | NA | NA | NA | D |
| Chromium VI | NA | 1.2E−02 (2) | 4.2E+01 (2) | NA | NA | Lung | NA | A |
| Cobalt | NA | NA | NA | NA | NA | NA | NA | D |
| Copper | NA | NA | NA | NA | NA | NA | NA | D |
| delta−BHC | 1.8E+00 (7) | 5.1E−04 (2) | 1.8E+00 (2) | 3.6E+00 (3) | Liver | Liver | NA | B2 |
| cis−1,2−Dichloroethene | NA | NA | NA | NA | NA | NA | NA | D |
| trans−1,2−Dichloroethene | NA | NA | NA | NA | NA | NA | NA | D |
| Hepatichlor Epoxide | 9.1E+00 (2) | 2.6E−03 (2) | 9.1E+00 (2) | 1.8E+01 (3) | Liver | Liver | NA | B2 |
| Lead | NA | NA | NA | NA | Kidney | NA | NA | B2 |
| Manganese (water/food) | NA | NA | NA | NA | NA | NA | NA | D |
| Mercury | NA | NA | NA | NA | NA | NA | NA | D |
| Methylene Chloride | 7.5E−03 (2) | 4.7E−07 (2) | 1.6E−03 (2) | 9.4E−03 (3) | Liver | Liver | NA | B2 |
| 4−Methylphenol (p−cresol) | NA | NA | NA | NA | Skin papillomas | NA | NA | C |
| Molybdenum | NA | NA | NA | NA | NA | NA | NA | D |
| Nickel | NA | NA | NA | NA | NA | NA | NA | D |
| Tetrachloroethene | 5.2E−02 (4) | 5.8E−07 (4) | 2.0E−03 (4) | 6.5E−02 (3) | Liver | Liver | NA | (6) |
| Toluene | NA | NA | NA | NA | NA | NA | NA | D |
| Trichloroethene | 1.1E−02 (4) | 1.7E−06 (4) | 6.0E−03 (4) | 1.4E−02 (3) | Liver | Liver | NA | (6), |
| Vanadium | NA | NA | NA | NA | NA | NA | NA | D |
| Vinyl Chloride | 1.9E+00 (5) | 8.4E−05 (5) | 3.0E−01 (5) | 2.4E+00 (3) | Lung, liver | Liver | NA | A |

(1) EPA, 1993a
(2) IRIS (EPA, 1993b)
(3) Absorption factors: 20% − inorganics, 50% − semivolatiles, 80% − volatiles
(4) ECAO (EPA, 1992c)
(5) HEAST (EPA, 1993c)
(6) No current position
(7) EPA Region III toxicity values for lindane

CSFo − Cancer Slope Factor (oral), (mg/kg/day)−1
Unit Risk − (ug/cu m)−1
CSFi − Cancer Slope Factor (inhalation), (mg/kg/day)−1
CSFd − Cancer Slope Factor (dermal), (mg/kg/day)−1
NA − Not Applicable

EPA Classification:
A − Human carcinogen
B − Probable human carcinogen
C − Possible human carcinogen
D − Not classifiable as a human carcinogen

Table 11
Reference Doses, Target Sites, and Confidence Levels for Contaminants of Concern
Contaminants of Concern
Bell Landfill Site
Towanda, Pennsylvania

| Contaminant of Concern | Reference Dose / Concentration | | | | Target Sites / Effects | | | Uncertainty Factor | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | RfDo | RfC | RfDI | RfDd | Oral | Inhalation | Dermal | Oral | Inhalation | Dermal |
| Acetone | 1E-01 (1) | NA | NA | 8E-02 (2) | Liver, kidney | NA | NA | 1,000 | NA | High |
| Aluminum | 2.9E+00 (3) | NA | NA | 6E-01 (2) | | | | | NA | High |
| Arsenic | 3E-04 (1) | NA | NA | 6E-05 (2) | Skin, blood vessels | NA | NA | 3 | NA | High |
| Barium | 7E-02 (1) | NA | NA | 1E-02 (2) | Increased blood pressure | NA | NA | 3 | NA | High |
| Benzene | NA | 5E-04 (5) | 1.4E-04 (5) | NA | NA | (3) | NA | (3) | NA | NA |
| Benzo(a)pyrene | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Beryllium | 5E-03 (1) | NA | NA | 1E-03 (2) | NOAEL | NA | NA | 100 | NA | High |
| Bis(2-Ethylhexyl)phthalate | 2E-02 (1) | NA | NA | 1E-02 (2) | Liver | NA | NA | 1,000 | NA | High |
| Cadmium | 5E-04 (1) | NA | NA | 1E-04 (2) | Proteinuria | NA | NA | 10 | NA | High |
| Chromium III | 1E+00 (1) | NA | 5.7E-07 (4) | 2E-01 (2) | NOAEL | NA | NA | 100 | NA | High |
| Chromium VI | 5E-03 (1) | NA | NA | 1E-03 (2) | NOAEL | NA | NA | 500 | NA | High |
| Cobalt (children) | 6E-02 (3) | NA | NA | 1E-02 (2) | | | NA | | NA | High |
| Cobalt (adult) | 1.8E-01 (3) | NA | NA | 4E-02 (2) | | | NA | | NA | High |
| Copper | 3.7E-02 (3) | NA | NA | 7E-03 (2) | | | NA | | NA | High |
| delta-BHC | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| cis-1,2-Dichloroethene | 1E-02 (4) | NA | NA | 8E-03 (2) | Decreased hemaocrit | NA | NA | 3,000 | NA | High |
| Trans-1,2-Dichloroethene | 2E-02 (1) | NA | NA | 2E-02 (2) | Serum alkaline phosphatase | NA | NA | 1,000 | NA | High |
| Repatchlor Epoxide | 1.3E-05 (1) | NA | NA | 7E-06 (2) | Liver | NA | NA | 1,000 | NA | High |
| Lead | NA | NA | NA | NA | CNS effects, blood | CNS effects, blood | NA | NA | NA | NA |
| Manganese (water) | 5E-03 (1) | NA | NA | 1E-03 (2) | CNS effects | NA | NA | 1 | NA | High |
| Manganese (food) | 1.4E-01 (1) | NA | NA | 3E-02 (2) | NOAEL | NA | NA | 1 | NA | High |
| Mercury | 3E-04 (4) | 3E-04 (4) | 8.6E-05 (4) | 6E-05 (2) | Kidney | Nervous system | NA | 30 | NA | High |
| Methylene Chloride | 6E-02 (1) | 3E+00 (4) | 8.6E-01 (4) | 5E-02 (2) | Liver | Liver | NA | 100 | NA | High |
| 4-Methylphenol (p-cresol) | 5E-03 (4) | NA | NA | 3E-03 (2) | Decreased weight gain | NA | NA | 1,000 | NA | High |
| Molybdenum | 5E-03 (1) | NA | NA | 1E-03 (2) | Increased uric acid | NA | NA | 30 | NA | High |
| Nickel | 2E-02 (1) | NA | NA | 4E-03 (2) | Decreased body weight | NA | NA | 300 | NA | High |
| Tetrachloroethene | 1E-02 (1) | NA | NA | 8E-03 (2) | Liver | NA | NA | 1,000 | NA | High |
| Toluene | 2E-01 (1) | 4E-01 | 1.1E-01 (4) | 2E-01 (2) | Liver, kidney | Nervous system | NA | 1,000 | 300 | High |
| Trichloroethene | 6E-03 (3) | NA | NA | 5E-03 (2) | | NA | | | | High |
| Vanadium | 7E-03 (4) | NA | NA | 1E-03 (2) | None observed | NA | NA | 100 | NA | High |
| Vinyl Chloride | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

(1) IRIS (EPA, 1993b)
(2) Absorption factors: 20% – Inorganics, 50% – semivolatiles, 80% – volatiles
(3) EPA Region III
(4) HEAST (EPA, 1993c)
RfDo Reference Dose (oral), (mg/kg/day)
RfC Reference Concentration, (mg/cu m)
RfDi Reference Dose (inhalation), (mg/kg/day)

This assumes that the mixture of contaminants present at the site has neither synergetic nor antagonistic interaction, and that all of the contaminants have the same mechanism of action in the same target organ to produce the same toxic endpoint.

The use of the conservative assumptions and models and the conservatism built into the toxicity values are believed to result in an overestimate of risk. Therefore, actual risk may be much lower than the estimates presented in this report, but is not likely to be greater.

# 5.0 RISK CHARACTERIZATION

In the final step of the baseline risk assessment, human intakes for each pathway of exposure are integrated with EPA reference toxicity values to characterize risk. Carcinogenic and noncarcinogenic effects are characterized separately.

To characterize the overall potential for noncarcinogenic effects associated with exposure to multiple chemicals, EPA has developed a Hazard Index (HI) approach. This approach assumes that simultaneous subthreshold chronic exposures to multiple chemicals that affect the same target organ are additive and could result in an adverse health effect. The HI is calculated as follows:

$$\text{Hazard Index} = ADD_1/RfD_1 + ADD_2/RfD_2 + \ldots ADD_i/RfD_i$$

where: $ADD_i$ = Average Daily Dose (ADD) for the ith toxicant

$RfD_i$ = Reference Dose for the ith toxicant

The term $ADD_i/RfD_i$ is referred to as the Hazard Quotient (HQ).

Calculation of a HI in excess of unity indicates the potential for adverse health effects. Indices greater than one will be generated anytime intake for any of the chemicals of concern exceeds its RfD. However, given a sufficient number of chemicals under consideration, it is also possible to generate a HI greater than one even if none of the individual chemical intakes exceeds its respective RfD.

Carcinogenic risk is expressed as a probability of developing cancer as a result of lifetime exposure. For a given chemical and route of exposure, excess lifetime cancer risk is calculated as follows:

Risk = Lifetime Average Daily Dose x Carcinogenic Slope Factor

These risks are probabilities that are generally expressed in scientific notation (i.e., $1 \times 10^{-6}$ or 1E-6). An excess lifetime cancer risk of $1 \times 10^{-6}$ indicates that, as a plausible upper-bound, an individual has a one-in-one-million chance of developing cancer as a result of site-related exposure to a carcinogen over a 70-year lifetime under the specific exposure conditions at the site. For exposures to multiple carcinogens, EPA assumes that the risk associated with multiple exposures is equivalent to the sum of their individual risks.

## 5.1 CURRENT USE

Currently complete exposure routes include inadvertent ingestion of leachate, dermal contact with leachate, inadvertent ingestion of soil, inhalation of dust, ingestion of water from private wells, inadvertent ingestion of surface water, dermal contact with surface water, inadvertent ingestion of sediment and dermal contact with sediment. Potential receptors are child trespassers, adult hunters, and residents who have private wells. Estimated risks associated with these exposure routes are summarized in **Table 12** and discussed separately below. Spreadsheets showing the input parameters and example calculations are presented in **Appendix B.**

Table 12
Summary of Cancer and Noncancer Risks by Exposure Route
*Current Use Scenario*
Bell Landfill Site
Towanda, Pennsylvania

| On-site Exposure | Exposure Route | Child Trespasser | | Adult Hunter | |
|---|---|---|---|---|---|
| | | Cancer | HI | Cancer | HI |
| AR300175 | Inadvertent Ingestion of Leachate | 5E-06 | 2.2 | 8E-06 | 1.2 |
| | Dermal Absorption of Leachate | 5E-06 | 0.3 | 2E-05 | 0.4 |
| | Inadvertent Ingestion of Soil | 6E-07 | 0.1 | 5E-07 | 0.02 |
| | Inhalation of Dust | 3E-09 | 1.00E-07 | 4E-09 | 1.00E-07 |
| | Inadvertent Ingestion of Surface Water | NA | 0.03 | NA | 0.02 |
| | Dermal Absorption of Surface Water | NA | 0.002 | NA | 0.002 |
| | Inadvertent Ingestion of Sediment | NA | 0.005 | NA | 0.001 |
| | Dermal Absorption of Sediment | NA | 0.001 | NA | 0.001 |
| | Total Current Risk | 1E-05 | 2.6 | 3E-05 | 1.6 |

| Private Well | Exposure Route | Child Resident | | 24-yr Adult Resident | | 30-yr Adult Resident | | Lifetime Resident (6-yr + 24-yr) | |
|---|---|---|---|---|---|---|---|---|---|
| | | Cancer | HI | Cancer | HI | Cancer | HI | Cancer | HI |
| A | Ingestion of Groundwater | NA | 0.4 | NA | 0.2 | NA | 0.2 | NA | 0.6 |
| | Dermal Absorption of Groundwater | NA | 0.001 | NA | NA | NA | NA | NA | 0.001 |
| | Total Current Risk | NA | 0.4 | NA | 0.2 | NA | 0.2 | NA | 0.6 |
| C | Ingestion of Groundwater | 1E-05 | 0.3 | 2E-05 | 0.1 | 3E-05 | 0.1 | 4E-05 | 0.4 |
| | Dermal Absorption of Groundwater | 6E-08 | 0.002 | NA | NA | NA | NA | 6E-08 | 0.002 |
| | Total Current Risk | 1E-05 | 0.3 | 2E-05 | 0.1 | 3E-05 | 0.1 | 4E-05 | 0.4 |
| D | Ingestion of Groundwater | 2E-05 | 0.6 | 4E-05 | 0.2 | 5E-05 | 0.2 | 6E-05 | 0.8 |
| | Dermal Absorption of Groundwater | 5E-08 | 0.001 | NA | NA | NA | NA | 5E-08 | 0.001 |
| | Total Current Risk | 2E-05 | 0.6 | 4E-05 | 0.2 | 5E-05 | 0.2 | 6E-05 | 0.8 |
| F | Ingestion of Groundwater | NA | 0.7 | NA | 0.3 | NA | 0.3 | NA | 1.0 |
| | Dermal Absorption of Groundwater | NA | 0.001 | NA | NA | NA | NA | NA | 0.001 |
| | Total Current Risk | NA | 0.7 | NA | 0.3 | NA | 0.3 | NA | 1.0 |

HI Hazard Index
NA Not Applicable

### 5.1.1 Leachate

#### 5.1.1.1 Inadvertent Ingestion

Child Trespassers - Noncancer effects are possible based on a HI of 2.2. Manganese, with an HQ of 2.1, is the main contributor to noncancer effects. No other COC has an HQ greater than one. The cancer risk estimate is $5 \times 10^{-6}$. Methylene chloride, a probable human carcinogen, and vinyl chloride, a known human carcinogen, are the main contributors to excess cancer risk.

Adult Hunters - Noncancer effects are possible based on a measured HI of 1.2. Manganese, with an HQ of 1.1, is the main contributor to noncancer effects. No other COC has an HQ greater than one. The cancer risk estimate is $8 \times 10^{-6}$. Methylene chloride and vinyl chloride are the main contributors to excess cancer risk.

#### 5.1.1.2 Dermal Absorption

Child Trespassers - Noncancer effects are not expected based on a measured HI of 0.3. The cancer risk estimate is $5 \times 10^{-6}$. Methylene chloride and vinyl chloride are the main contributors to excess cancer risk.

Adult Hunters - The HI, a measure of noncancer risk, is 0.4, suggesting that noncancer effects are not expected. The cancer risk estimate is $2 \times 10^{-5}$. Methylene chloride and vinyl chloride are the main contributors to excess cancer risk.

1.2 Surface Soil

5.1.2.1 Inadvertent Ingestion

Child Trespassers - The HI, a measure of noncancer risk, is 0.1, suggesting that noncancer effects are not expected. The cancer risk estimate is $6 \times 10^{-7}$. Arsenic, a known human carcinogen via the oral route of exposure, is the main contributor to excess cancer risk.

Adult Hunters - The HI, a measure of noncancer risk, is 0.02, suggesting that noncancer effects are not expected. The cancer risk estimate is $5 \times 10^{-7}$. Arsenic is the main contributor to excess cancer risk.

5.1.2.2 Inhalation of Dust

Child Trespassers - Mercury is the only COC present in soil for which an EPA approved RfD via inhalation has been established. Based on an HI of 0.0000001, noncancer effects are not expected. The cancer risk estimate is $3 \times 10^{-9}$. Cadmium, a probable human carcinogen via the inhalation route of exposure, and chromium, a known human carcinogen via inhalation exposure, are the main contributors to excess cancer risk. Risks associated with chromium exposure may be overstated since it was conservatively assumed to be present in the hexavalent state, an assumption which may not be valid.

Adult Hunters - Based on a HI of 0.0000001, noncancer effects are not expected. The cancer risk estimate is $4 \times 10^{-9}$. Cadmium and chromium are the main contributors to excess cancer risk.

### 5.1.3 Groundwater (Residential Wells)

#### 5.1.3.1 Ingestion

Resident C - Child - The HI, a measure of noncancer risk, is 0.3, suggesting that noncancer effects are not expected. The cancer risk estimate is $1 \times 10^{-5}$. Arsenic, a known human carcinogen via the oral route of exposure, is the main contributor to excess cancer risk.

Resident C - 24-yr Adult - The HI, a measure of noncancer risk, is 0.1, suggesting that noncancer effects are not expected. The cancer risk estimate is $2 \times 10^{-5}$. Arsenic is the main contributor to cancer risk.

Resident C - 30-yr Adult - The HI, a measure of noncancer risk, is 0.1, suggesting that noncancer effects are not expected. The cancer risk estimate is $3 \times 10^{-5}$. Arsenic is the main contributor to cancer risk.

Resident D - Child - The HI, a measure of noncancer risk, is 0.6, suggesting that noncancer effects are not expected. The cancer risk is $2 \times 10^{-5}$ based solely on the detected presence of arsenic, a known human carcinogen.

Resident D - 24-yr Adult - The HI, a measure of noncancer risk, is 0.2, suggesting that noncancer effects are not expected. The cancer risk is $4 \times 10^{-5}$ based solely on the detected presence of arsenic.

Resident D - 30-yr Adult - The HI, a measure of noncancer risk, is 0.2, suggesting that noncancer effects are not expected. The cancer risk is $5 \times 10^{-5}$ based solely on the detected presence of arsenic.

Resident F - Child - The HI, a measure of noncancer risk, is 0.7, suggesting that noncancer effects are not expected. No carcinogens were identified in private well F.

Resident F - 24-yr Adult - The HI, a measure of noncancer risk, is 0.3, suggesting that noncancer effects are not expected. No carcinogens were identified in private well F.

Resident F - 30-yr Adult - The HI, a measure of noncancer risk, is 0.3, suggesting that noncancer effects are not expected. No carcinogens were identified in private well F.

Resident A - Child - The HI, a measure of noncancer risk, is 0.4, suggesting that noncancer effects are not expected. No carcinogens were identified in private well F.

Resident A - 24-yr Adult - The HI, a measure of noncancer risk, is 0.2, suggesting that noncancer effects are not expected. No carcinogens were identified in private well F.

Resident A - 30-yr Adult - The HI, a measure of noncancer risk, is 0.2, suggesting that noncancer effects are not expected. No carcinogens were identified in private well F.

5.1.3.2 Dermal Absorption

Resident C - Child - The HI, a measure of noncancer risk, is 0.002, suggesting that noncancer effects are not expected. The cancer risk estimate is $6 \times 10^{-8}$. Bis(2-ethylhexyl)phthalate, a probable human carcinogen via the oral route and by inference the dermal route, is the main contributor to excess cancer risk.

Resident D - Child - The HI, a measure of noncancer risk, is 0.001, suggesting that noncancer effects are not expected. The cancer risk is estimated at $5 \times 10^{-8}$ based solely on the detected presence of arsenic. Arsenic is a known human carcinogen via the oral, and by inference, the dermal route of exposure.

Resident F - Child - The HI, a measure of noncancer risk, is 0.001, suggesting that noncancer effects are not expected. No carcinogens were detected in private well F.

Resident A - Child - The HI, a measure of noncancer risk, is 0.001, suggesting that noncancer effects are not expected. No carcinogens were detected in private well A.

5.1.4 Surface Water

5.1.4.1 Inadvertent Ingestion

Child Trespassers - The HI, a measure of noncancer risk, is 0.03, suggesting that noncancer effects are not expected. No carcinogens were selected as COCs for surface water.

Adult Hunters - The HI, a measure of noncancer risk, is 0.02, suggesting that noncancer effects are not expected. No carcinogens were selected as COCs for surface water.

5.1.4.2 Dermal Absorption

Child Trespassers - The HI, a measure of noncancer risk, is 0.002, suggesting that noncancer effects are not expected. No carcinogens were selected as COCs for surface water.

Adult Hunters - The HI, a measure of noncancer risk, is 0.002, suggesting that noncancer effects are not expected. No carcinogens were selected as COCs for surface water.

5.1.5 Sediment

5.1.5.1 Inadvertent Ingestion

Child Trespassers - The HI, a measure of noncancer risk, is 0.005, suggesting that noncancer effects are not expected. No carcinogens were selected as COCs for sediment.

Adult Hunters - The HI, a measure of noncancer risk, is 0.001, suggesting that noncancer effects are not expected. No carcinogens were selected as COCs for sediment.

5.1.5.2 Dermal Absorption

Child Trespassers - The HI, a measure of noncancer risk, is 0.001, suggesting that noncancer effects are not expected. No carcinogens were selected as COCs for sediment.

Adult Hunters - The HI, a measure of noncancer risk, is 0.001, suggesting that noncancer effects are not expected. No carcinogens were selected as COCs for sediment.

5.1.6 Current Use Risk Summary

The cancer and noncancer risks for the current use scenario are summarized by exposure route in Table 12. As measured by HIs of 2.6, 1.6, and 1.0, noncancer effects are possible for a child trespasser, an adult hunter and a lifetime resident using water from private well F. For each receptor, manganese is the main contributor to possible noncancer health effects. Inadvertent ingestion of leachate containing high levels of manganese is the most important exposure route for the child trespasser and adult hunter. Ingestion of water containing high levels of manganese is the most significant exposure route for lifetime resident F. Noncancer effects are not expected for child or adult residents A, C or D or for lifetime residents A, C or D (child through adult).

Cancer risk estimates range from $1 \times 10^{-5}$ for a child trespasser to $6 \times 10^{-5}$ for lifetime resident D. Exposure to leachate containing high levels of methylene chloride and vinyl chloride via inadvertent ingestion and dermal absorption are the main exposure routes for the child trespasser. Ingestion of water containing quantities of arsenic and accounts for the excess cancer risk associated with Resident D. EPA's acceptable target range for carcinogenic risk at Superfund sites is one-in-ten-thousand ($1 \times 10^{-4}$) to one-in-one-million ($1 \times 10^{-6}$). The quantifiable excess carcinogenic risks for the current use scenario are within EPA's acceptable target range.

## 5.2 FUTURE USE

Future risks posed by the site consider residential or commercial development of the site. Included in this scenario is the development of water supply wells for domestic or commercial use within the area of the identified contaminant plume. Potential receptors include child and adult residents as well as adult workers. The exposure routes are the same as those identified in the current use scenario with the addition of inhalation of volatile organic compounds (VOCs) released from groundwater while showering. Risks attributable to each exposure route are summarized in **Table 13**. Spreadsheets showing the input parameters are presented in **Appendix C**.

### 5.2.1 Leachate

#### 5.2.1.1 Inadvertent Ingestion

Child Residents - The HI, a measure of noncancer risk, is 22.0, suggesting that noncancer effects are possible. Manganese, with an HQ of 20.5, is the main contributor to noncancer risk. The cancer risk estimate is $3 \times 10^{-5}$ due mainly to the detected presence of methylene chloride, a probable human carcinogen.

Table 13
Summary of Cancer and Noncancer Risks by Exposure Route
Future Use Scenario
Bell Landfill Site
Towanda, Pennsylvania

| Exposure Route | Child Resident | | 24-yr Adult Resident | | 30-yr Adult Resident | | Lifetime Resident (6-yr + 24-yr) | | Adult Worker | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Cancer | HI | Cancer | HI | Cancer | HI | Cancer | HI | Cancer | HI |
| Inadvertent Ingestion of Leachate | 3E-05 | 22.0 | NA | NA | NA | NA | 3E-05 | 22.0 | NA | NA |
| Dermal Absorption of Leachate | 1E-05 | 1.7 | NA | NA | NA | NA | 1E-05 | 1.7 | NA | NA |
| Inadvertent Ingestion of Soil | 2E-05 | 5.0 | NA | NA | NA | NA | 2E-05 | 5.0 | 4E-06 | 0.2 |
| Inhalation of Dust | 5E-08 | 0.000003 | NA | NA | NA | NA | 5E-08 | 0.0 | 3E-08 | 0.00000005 |
| Ingestion of Groundwater | 4E-04 | 36.9 | 7E-04 | 15.8 | 9E-04 | 15.8 | 1E-03 | 52.7 | 3E-04 | 5.6 |
| Dermal Absorption of Groundwater | 2E-06 | 0.1 | NA | NA | NA | NA | 2E-06 | 0.1 | NA | NA |
| Inhalation of VOCs | NA | NA | 3E-05 | 0.3 | 3E-05 | 0.3 | 3E-05 | 0.3 | 2E-05 | 0.2 |
| Inadvertent Ingestion of Surface Water | NA | 0.3 | NA | NA | NA | NA | NA | 0.3 | NA | NA |
| Dermal Absorption of Surface Water | NA | 0.01 | NA | NA | NA | NA | NA | 0.01 | NA | NA |
| Inadvertent Ingestion of Sediment | NA | 0.05 | NA | NA | NA | NA | NA | 0.05 | NA | NA |
| Dermal Absorption of Sediment | NA | 0.004 | NA | NA | NA | NA | NA | 0.004 | NA | NA |
| Total Future Risk | 5E-04 | 66.1 | 7E-04 | 16.1 | 9E-04 | 16.1 | 1E-03 | 82.2 | 4E-04 | 6.0 |

HI Hazard Index
NA Not Applicable
VOCs Volatile Organic Compounds

5.2.1.2 Dermal Absorption

Child Residents - The HI, a measure of noncancer risk, is 1.7, suggesting that noncancer effects are possible. Manganese, with an HQ of 1.2, is the main contributor to noncancer risk. The cancer risk estimate is $1 \times 10^{-5}$ due mainly to the detected presence of methylene chloride.

5.2.2 Surface Soil

5.2.2.1 Inadvertent Ingestion

Child Residents - The HI, a measure of noncancer risk, is 5.0, suggesting that noncancer effects are possible. Cadmium, with an HQ of 3.4, is the main contributor to noncancer risk. The cancer risk estimate is $2 \times 10^{-5}$ due mainly to the detected presence of arsenic, a known human carcinogen via the oral route of exposure.

Adult Workers - The HI, a measure of noncancer risk, is 0.2, suggesting that noncancer effects are not expected. The cancer risk estimate is $4 \times 10^{-6}$ due mainly to the detected presence of arsenic.

5.2.2.2 Inhalation of Dust

Child Residents - Mercury is the only COC with an EPA approved RfD via the inhalation route of exposure. The calculated HI based on exposure to mercury via inhalation of dust is 0.000003, suggesting that noncancer effects are not expected. The cancer risk estimate is $5 \times 10^{-8}$. Chromium, conservatively assumed to be present in the hexavalent form which is a known human carcinogen, and cadmium, a probable human carcinogen via the inhalation route, are the main contributors to excess cancer risk.

Adult Workers - The calculated HI based on exposure to mercury via inhalation of dust is 0.0000005, suggesting that noncancer effects are not expected. The cancer risk estimate is 3 x $10^{-8}$. Chromium and cadmium are the main contributors to excess cancer risk.

5.2.3 Groundwater (Monitoring Wells)

5.2.3.1 Ingestion

Child Residents - The HI, a measure of noncancer risk, is 36.9, indicating that noncancer effects are possible. Manganese, with an HQ of 24.9, and arsenic, with an HQ of 6.7, are the main contributors to noncancer risk. The cancer risk estimate is 4 x $10^{-4}$. Arsenic is the main contributor to excess cancer risk.

4-yr Adult Residents - The HI, a measure of noncancer risk, is 15.8, indicating that noncancer effects are possible. Manganese, with an HQ of 10.7, and arsenic, with an HQ of 2.9, are the main contributors to noncancer risk. The cancer risk estimate is 7 x $10^{-4}$. Arsenic is the main contributor to cancer risk.

30-yr Adult Residents - The HI, a measure of noncancer risk, is 15.8, indicating that noncancer effects are possible. Manganese and arsenic are the main contributors to noncancer risk. The cancer risk estimate is 9 x $10^{-4}$. Arsenic is the main contributor to cancer risk.

Adult Workers - The HI, a measure of noncancer risk, is 5.6, indicating that noncancer effects are possible. Manganese and arsenic are the main contributors to noncancer risk. The cancer risk estimate is 3 x $10^{-4}$. Arsenic is the main contributor to cancer risk.

5.2.3.2 Dermal Absorption

Child Residents - The HI, a measure of noncancer risk, is 0.1, indicating that noncancer effects are not expected. The cancer risk estimate is $2 \times 10^{-6}$. Vinyl chloride is the main contributor to excess cancer risk.

5.2.3.3 Inhalation of Vapors

24-yr Adult Residents - The HI is 0.3 indicating that noncancer effects are not expected. The excess cancer risk estimate is $3 \times 10^{-5}$. Vinyl chloride is the main contributor to excess cancer risk.

30-yr Adult Residents - The HI is 0.3 indicating that noncancer effects are not expected. The excess cancer risk estimate is $3 \times 10^{-5}$. Vinyl chloride is the main contributor to excess cancer risk.

Adult Workers - The HI is 0.2 indicating that noncancer effects are not expected. The cancer risk estimate is $2 \times 10^{-5}$. Vinyl chloride is the main contributor to cancer risk.

5.2.4 Surface Water

5.2.4.1 Inadvertent Ingestion

Child Residents - The HI, a measure of noncancer risk, is 0.3, indicating that noncancer effects are not expected. There were no carcinogenic COCs identified in surface water.

5.2.4.2 Dermal Absorption

Child Residents - The HI, a measure of noncancer risk, is 0.01, indicating that noncancer effects are not expected. There were no carcinogenic COCs identified in surface water.

5.2.5 Sediment

5.2.5.1 Inadvertent Ingestion

Child Residents - The HI, a measure of noncancer risk, is 0.05, indicating that noncancer effects are not expected. There were no carcinogenic COCs identified in sediment.

5.2.5.2 Dermal Absorption

Child Residents - The HI, a measure of noncancer risk, is 0.004, indicating that noncancer effects are not expected. There were no carcinogenic COCs identified in sediment.

5.2.6 Exposure to Lead

Neither a cancer slope factor nor reference dose value is available for lead. Instead, blood lead concentrations have been accepted as the best measure of exposure. The EPA has developed a biokinetic/uptake model to assess chronic, noncancer exposures of children to lead (EPA 1991e). Version 0.50 of the model was used to evaluate exposures of child residents to lead.

The arithmetic mean of lead concentrations (using one-half the sample quantitation limit where no lead was detected) in surface soil and groundwater (MW-2, -3, -5, and -6) were used as the input for the model. Default values for lead in air and dietary ingestion were used. No contribution from paint ingestion was included. The results of the model are presented in **Appendix D** and summarized in **Table 14**. EPA uses a blood lead level of 10 $\mu$g/dL as the benchmark to evaluate lead exposure. Based on the above assumptions, projected blood lead levels are below 10 $\mu$g/dL for all age groups.

Table 14
Projected Blood Lead Levels in Children
Future Use Scenario
Bell Landfill Site
Towanda, Pennsylvania

| Soil/Dust Lead (mg/kg) | Water Lead (ug/L) | Blood Lead Levels (ug/dL) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Year 0.5–1 | Year 1–2 | Year 2–3 | Year 3–4 | Year 4–5 | Year 5–6 | Year 6–7 |
| 644 | 19.4 | 5.47 | 5.66 | 5.80 | 5.93 | 6.16 | 6.22 | 6.25 |

Source: Uptake/Biokinetic Model, Version 0.5

Assumptions:
Air concentration: 0.200ug Pb/m3 (default)
Diet (default)
Paint intake: 0.00 ug Pb/day (default)
Maternal contribution: Infant model (default)
Water contribution: 19.4 ug/L (average concentration in monitoring wells)
Arithmetic average lead concentration in soil

## 5 Future Use Risk Summary

Future use risks are evaluated in this risk assessment since there is a possibility that groundwater of the quality represented by the center of the groundwater plume may migrate to areas where receptors may become exposed to it. The cancer and noncancer risks are summarized by exposure route in Table 13.

As measured by HIs of 66.1, 16.1, 16.1, 82.2 and 6.0, noncancer effects are possible for child residents, 24- and 30-yr adult residents, lifetime residents and adult workers. In each case, ingestion of groundwater from a well constructed in the contaminant plume containing high levels of manganese is the main contributor to noncancer risk.

Cancer risk estimates range from $4 \times 10^{-4}$ for an adult worker to $1 \times 10^{-3}$ for a lifetime resident. Ingestion of groundwater containing arsenic is the major contributor to increased cancer risk. EPA's acceptable target range for carcinogenic risk at Superfund sites is one-in-ten-thousand ($1 \times 10^{-4}$) to one-in-one-million ($1 \times 10^{-6}$). The quantifiable carcinogenic risks for the future use scenario are outside EPA's acceptable range.

Based on the Agency's uptake/biokinetic model, projected blood levels for children are below EPA's benchmark of 10 $\mu$g/dL for all age groups.

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# Appendix A

## Toxicological Profiles of

## Contaminants of Concern

## APPENDIX A CONTENTS

## APPENDIX A CONTENTS (continued)

## Acetone

Acetone is a highly volatile, highly water-soluble aliphatic ketone. Acetone is readily absorbed by the lungs and gastrointestinal (GI) tract, taken up by the blood, and widely distributed to organs and tissues of the body. Acetone can also be absorbed dermally.

Acetone is irritating to mucous membranes, and exposure to the vapors can irritate the respiratory system and eyes. Acetone has anesthetic properties and causes headaches, light-headedness, confusion, dizziness, and can lead to unconsciousness and coma in humans at high exposure levels. Neurobehavioral and hematological effects have been observed in humans exposed to acetone. Acute inhalation may shorten the menstrual cycle. Exposure to acetone vapor can also lead to GI irritation, nausea, vomiting, and hemorrhage. Ingestion of acetone can cause erosions in the mouth, coma, and diabetes-like symptoms. Acute dermal exposure to liquid acetone results in degenerative changes in the epidermis and contact dermatitis.

Because of its high water solubility, precipitation can remove acetone from the air to surface water and soil. In water and soil acetone undergoes microbial degradation but can also evaporate back to the atmosphere, depending on the moisture content of soil. Adsorption to soil is inconsequential. Acetone does not accumulate in fish or other aquatic or terrestrial organisms.

No studies were located regarding cancer in humans or animals after inhalation or oral exposure, or in humans after dermal exposure to acetone. EPA has classified acetone in Group D, not classifiable due to the lack of data concerning carcinogenicity in humans or animals (ATSDR, 1993).

## Aluminum

Aluminum is not thought to be harmful to humans in the forms normally encountered (e.g., via cooking utensils, antacids, and antiperspirants). However, exposure to aluminum is not beneficial and excess exposure may be harmful to certain people. Sensitive subpopulations may include pregnant women and Alzheimer's patients. The potential health risks associated with exposure to aluminum include respiratory problems from breathing the dust, and possibly neurological, teratogenic, and skeletal problems from drinking water containing high levels of aluminum. Inhalation and dermal exposure of healthy subjects are not associated with adverse health risks.

Aluminum is not known to cause cancer in humans. Some workers in the aluminum industry have had a higher than expected incidence of cancer, but this is probably due to the other potent carcinogens to which they are exposed, such as polycyclic aromatic hydrocarbons and tobacco smoke. The few animal studies that were available were designed to study noncancer endpoints, but they also do not indicate that aluminum is carcinogenic (ATSDR, 1991a).

## Arsenic

Arsenic is a potent toxicant that may exist in several valence states and in a number of inorganic and organic forms. Most cases of arsenic-induced toxicity in humans are due to exposure to inorganic arsenic, and there is an extensive database on the human health effects of the common arsenic oxides and oxyacids. Although there may be some differences in the potency of different chemical forms (e.g., arsenites tend to be somewhat more toxic than arsenates), these differences are usually minor.

Exposure to arsenic via inhalation is a great public health concern due to the increased risk of lung cancer, although respiratory irritation, nausea, and skin effects may also occur. Several studies have shown an increased risk of lung cancer in workers occupationally exposed. Based on the risk of lung cancer, EPA has assigned inorganic arsenic to Group A (known human carcinogen) via the inhalation route.

By the oral route, the effects most likely to be of human health concern are GI irritation, peripheral neuropathy, vascular lesions, anemia, and a group of skin diseases, including skin cancer. Based on epidemiological studies which have shown an increased risk of skin cancer in populations exposed to elevated levels of arsenic in drinking water, EPA has placed inorganic arsenic in Group A (known human carcinogen) by the oral route of exposure.

Relatively little information is available on effects due to direct dermal contact with inorganic arsenicals, but several studies indicate the chief effect is local irritation and dermatitis, with little risk of other adverse effects (ATSDR, 1992a).

**Benzene Hexachloride (BHC) - Alpha-, Beta-, and Gamma - (Lindane)**

The primary health effects associated with exposure to BHC are hematological effects, hepatic effects, renal effects, immunological effects, neurological effects, and reproductive effects.

Hepatic effects, such as increased liver enzymes, have been reported in humans while increased microsomal activity, increased liver weight, hypertrophy, mild to moderate liver necrosis, and fatty degeneration have been reported in animals.

In humans, neurological effects from BHC exposure have resulted in paresthesia of the face and extremities, headaches, vertigo, abnormal EEG patterns, and seizures and convulsions. BHC has been known to cause spontaneous abortions and premature deliveries in women; alterations in reproductive hormones were detected in women.

Hepatocellular carcinoma is the most frequently reported tumor type found from BHC exposure studies in animals. A metabolite of gamma-BHC, 2,4,6-trichlorophenol (2,4,6-TCP), has been classified by EPA as a group B2 compound (ATSDR, 1989a).

## Barium

Humans exposed to acute levels of barium have shown respiratory, gastrointestinal, cardiovascular, renal, and neurological effects. Respiratory effects of benign pneumonoconiosis have been observed in workers exposed occupationally by inhalation to barium. Respiratory weakness and paralysis were seen in humans following ingestion of barium. Acute ingestion of barium has also lead to cardiovascular effects of increased blood pressure, changes in heart rhythm, myocardial damage, and changes in heart physiology and metabolism and gastrointestinal effects of hemorrhaging, pain, vomiting, and diarrhea. Renal effects of degeneration and failure and neurological effects of numbness and tingling of the mouth and neck, partial and complete paralysis, and brain congestion and edema were reported in the human case studies (ATSDR, 1991).

Barium has not been evaluated by EPA for human carcinogenic potential (ATSDR, 1991b).

## Benzene

Benzene exposure affects the CNS, blood, and skin. Neurological effects from exposure are seen in symptoms of drowsiness, dizziness, headache, vertigo, tremor, delirium, and loss of consciousness. Abnormalities in motor conduction velocity are often seen in workers exposed to benzene.

The most noted systemic effect resulting from intermediate and chronic benzene exposure is hematotoxicity. A common clinical finding in benzene hematotoxicity is cytopenia, which is a decrease in various cellular elements of the circulating blood manifested as anemia, leukopenia, or thrombocytopenia in humans. Furthermore, a causal relationship exists between benzene exposure and aplastic anemia in humans. This disorder is characterized by reduction of all cellular elements in the peripheral blood and in bone marrow. Aplastic anemia that results from benzene exposure is also associated with an increased risk of developing acute nonlymphocytic leukemia.

Both gastrointestinal (i.e., toxic gastritis and pyloric stenosis) and dermal effects (i.e., swelling and edema) have been reported to occur in a human who swallowed benzene. A study conducted in rabbits lends support to the finding that benzene is irritating and damaging to the skin and also shows that it is irritating and damaging to the eyes following dermal/ocular application.

Several in vivo and in vitro studies conclusively demonstrated that benzene can be readily absorbed through human skin. Benzene defats the keratin layer; causes erythema and vesiculation; and dries the dermatitis producing scales.

Inhalation of high levels of benzene has produced various developmental effects in animals: decreased fetal weight, minor skeletal variants, and hematopoietic anomalies. Some effects on testes such as atrophy/degeneration, decrease in spermatozoa, and moderate increases in abnormal sperm forms have been noted in animals exposed by inhalation. Benzene also seems to be genotoxic to humans, causing primarily chromosomal aberrations. Peripheral lymphocytes and bone marrow cells appear to be the major targets.

Benzene is considered to be a human carcinogen by EPA, OSHA, the World Health Organization (WHO), and the International Agency for Research on Cancer (IARC). EPA has verified the weight-of-evidence classification for carcinogenicity of benzene as EPA Group A, based on a sufficient level of human evidence supported by a sufficient level of animal evidence. It is established that exposure to commercial benzene or benzene-containing mixtures can cause damage to the hematopoietic system including pancytopenia with subsequent manifestation of leukemia (ATSDR, 1992b).

## Beryllium

The respiratory tract in humans and animals is the primary target of inhalation exposure to beryllium and its compounds. Inhalation of some forms of beryllium can cause obstructive and restrictive diseases of the lung, known as chronic beryllium disease (berylliosis); inhalation of high concentrations can cause chemical pneumonitis. The heart is an indirect target organ for beryllium in humans, monkeys, and dogs, with effects probably secondary to the respiratory effects. Renal effects have been observed in animals inhaling low concentrations of beryllium oxide, as indicated by proteinuria. Hepatic effects were not observed in humans or animals, unless the concentrations were high enough to be lethal. Dermal exposure causes the formation of skin granulomas in the intact skin of sensitized individuals.

Epidemiology studies suggest an increased risk of lung cancer due to occupational exposure to beryllium. Increased incidences of lung cancer were observed among workers at beryllium extraction, processing, and fabrication facilities. Human and animal data suggest that beryllium is considered carcinogenic in animals and is a suspect or probable human carcinogen (ATSDR, 1992c).

## Bis(2-ethylhexyl)phthalate (Di(2-ethylhexyl)phthalate)

There is currently no evidence of adverse health effects in humans, but animal data show that bis(2-ethylhexyl)phthalate (di(2-ethylhexyl)phthalate DEHP) can have effects on the liver, testes, kidney, thyroid, and pancreas. Fertility of both males and females can be affected; gestational exposure to DEHP may cause birth defects.

It is possible that exposure to DEHP through dialysis has an adverse effect on the human kidney. An increase in polycystic kidney disease has been reported in long-term hemodialysis patients. Although it is not possible to confirm a causative role for DEHP in this effect, data from animal studies indicate that DEHP may be toxic to the kidneys. Acute exposures of rats to DEHP can cause an increase in kidney weight and enlarged lysosomes in the tubules.

No studies were located regarding developmental effects in humans after exposure to DEHP. Developmental toxicity did occur in both mice and rats orally exposed to DEHP throughout the gestation period. Neonatal weight and survival were reduced in exposed animals; fetal malformations (external, visceral, and skeletal defects) were present in both species but were only statistically significant for the rats. Malformations were present in the kidneys and heart.

No studies were located regarding reproductive effects in humans after exposure to DEHP. There are multiple studies in rats where DEHP increased the weights of the testes, prostate, seminal vesicles, and epididymis. Atrophy and degeneration of the testicular tubules occurred and the process of spermatogenesis was altered.

No studies were located regarding cancer in humans after exposure to DEHP. However, long-term exposure of rodents to DEHP causes cancer of the liver in both rats and mice. There is also a proliferation of preneoplastic nodules in the liver of rats even when no carcinomas are present. As a result of these studies, DEHP has been classified in EPA Group B2, probable human carcinogen (ATSDR, 1992f).

## Cadmium

The target organs for cadmium exposure are the gastrointestinal tract and the kidneys. Gastrointestinal effects after ingestion of cadmium are nausea, vomiting, and abdominal pain. An interconnection exists between renal effects and musculoskeletal effects when examining cadmium exposure to humans. Evidence from both human and animal studies suggests that lower level chronic exposure to cadmium causes alterations in renal metabolism of vitamin D, which then may cause mild bone effects. Cadmium exposure may also lead to respiratory effects resulting in the destruction of lung epithelial cells, pulmonary edema, tracheobronchitis, and pneumonitis, and hematological effects causing anemia.

The evidence that cadmium inhalation can cause lung cancer in humans is weak, but strong evidence exists that cadmium inhalation can cause lung cancer in rats. Animal studies have also shown that injection of cadmium into the skin or muscle causes tumors in rats, primarily at the site of injection and in the testes. EPA has classified cadmium as a probable human carcinogen by inhalation (Group B1), based on the positive responses in humans and in rats (ATSDR, 1992d).

## Chromium

Most of the toxic effects associated with chromium compounds are attributed to the more highly soluble, irritating hexavalent form of chromium. Trivalent chromium is considered one of the least toxic of the trace metals. Inhalation exposures to hexavalent chromium compounds have been associated with nasal damage, such as perforated septa, nosebleeds, and inflamed mucosa. Skin contact with high levels of chromium compounds has been reported to produce an eczema-like condition.

Hexavalent chromium is suspected of being responsible for mutagenic and cell transforming effects of chromates in various test systems. These adverse effects appear to be prevented in the presence of liver enzymes or gastric juice, but are unaffected by lung enzymes.

Hexavalent chromium is classified as a Group A human carcinogen by inhalation, based on sufficient evidence of human carcinogenicity. Results of epidemiologic studies are consistent across investigators and locations. Studies of chromate production facilities in the U.S., Great Britain, Japan, and Germany have established an association between chromium exposure and lung cancer. Three studies of the chrome pigment industry in Norway, England, and the Netherlands found an association between occupational chromium exposure and lung cancer (ATSDR, 1992e).

## Cobalt

Stable cobalt has been found to produce adverse effects by the inhalation, oral, and dermal routes. Effects in humans following inhalation exposure to cobalt included lung effects (respiratory irritation, fibrosis, asthma, pneumonia, wheezing), cardiovascular effects (cardiomyopathy), liver and kidney congestion, ocular effects (congestion of the conjunctiva), and weight loss. Cobalt dermatitis and sensitization were well documented as a result of dermal exposure to cobalt.

Cobalt has not been shown to cause cancer in humans by any exposure route. An occupational study reported an increased incidence of death from lung cancer in workers occupationally exposed to cobalt but the difference was not statistically significant. The induction of tumors following intramuscular injection into rats and subcutaneous injection into mice was shown; however, the significance of these results to humans is not clear because these are not relevant routes of exposure and no tumors were found in humans with metal-alloy prostheses (ATSDR, 1991c).

## Copper

Noncarcinogenic effects observed in humans are gastrointestinal hepatic, renal, dermal, neurological, and possibly developmental effects. Ingestion of high levels of copper has produced gastrointestinal effects of vomiting, nausea, diarrhea, and anoxemia. Centrilobular necrosis of the liver and necrosis and sloughing of tubular cells in the kidney have been observed in individuals dying from copper poisoning. Dermal exposure to copper results in contact allergic dermatitis in some individuals (ATSDR, 1990a).

Copper toxicity in humans can also lead to Wilson's disease, an autosomal recessive disorder that affects normal copper homeostasis. The systemic manifestation of Wilson's disease are hepatic and renal lesions and hemolytic anemia. The disease also debilitates the central nervous system causing poor coordination, psychological impairment, tremor, disturbed gait, and rigidity (ATSDR, 1990a).

Although developmental effects have not been reported in humans, there is a possibility that there may be an increased incidence of spontaneous abortion and miscarriage in women exposed to high levels of copper.

An elevated incidence of cancer has not been observed in humans or animals exposed to copper via inhalation, oral, or dermal routes of exposure (ATSDR, 1990a).

## 1,2-Dichloroethene

Clinical symptoms that have been reported in humans exposed to 1,2-dichloroethene (DCE) in air include nausea, drowsiness, fatigue, intracranial pressure and ocular irritation. One fatality has been reported. No information is available on the toxicity of ingested DCE in humans. No information is available on the relative toxicities of the cis- and trans- isomers of DCE in humans. Symptoms described in animals exposed to DCE include pathological lesions in the heart, liver, and lung. However, evidence for serious adverse effects in these organs consists of only one study, seriously constraining any conclusions that can be drawn about the relevance of these effects to humans. Ataxia and respiratory depression occur in the terminal stages prior to death in animals. Since these symptoms have not been observed in humans, their relevance to public health is not known.

To date, cancer effects of cis- and trans-1,2-dichloroethene have not been studied in humans or animals (ATSDR, 1990b).

## Heptachlor and Heptachlor Epoxide

Although little quantitative data on exposures and measurable adverse health effects exist for humans, there is evidence that heptachlor and heptachlor epoxide can cause adverse effects if exposure is sufficient in duration and/or dose. Heptachlor is one of the cyclodiene pesticides designed to act as a neurotoxicant in insects. It is not surprising, therefore, that the central nervous system can be identified as one of the target systems of this compound in humans and animals. The liver is also a target organ for heptachlor and heptachlor epoxide. The findings of change in liver enzymes and histopathology in several animal species indicate that the liver would be a target for humans also.

Existing epidemiological studies on heptachlor are considered inadequate to establish a clear qualitative or quantitative assessment of heptachlor exposure and human risk of developing cancer. The large occupational cohort mortality studies conducted on workers engaged in the manufacture of heptachlor have not identified a statistically significant increase in cancer death. Chronic oral exposure to heptachlor and heptachlor epoxide increased the incidence of liver carcinomas in rats and mice. Heptachlor and heptachlor epoxide are classified as possible human carcinogens, Group B2, under EPA's guidelines for carcinogen risk assessment based on the positive cancer findings in animals studies (ATSDR, 1992g).

## Lead

At high exposure levels, lead produces encephalopathy, gastrointestinal effects, anemia, nephropathy, and electrocardiographic abnormalities. These effects are primarily seen in children or from occupational exposure. Lower level exposure to lead in all humans can affect the synthesis of heme, which in turn affects metabolic processes and decreases vitamin D circulating in the body which reduces calcium stability in the body.

Effects of great concern from low-level lead exposure are neurobehavioral effects and growth retardation in infants exposed prenatally and children exposed postnatally. Increased blood pressure from low-level lead exposure in middle-aged men has also been observed. Based on blood lead concentrations, no clear threshold of effect has been shown from low-level lead exposures resulting in blood lead levels $< 10$ ug/dl.

Lead has also been shown in a number of DNA structure and function assays to affect the molecular processes associated with the regulation of gene expression, and under certain conditions, may induce chromosomal aberrations in vivo and in tissue cultures. No reproductive effects from human oral exposure to lead have been reported; however, occupational inhalation exposures have been linked to altered testicular function, increases in spontaneous abortion, premature delivery, and early membrane rupture.

The EPA has classified lead as a Group B2 carcinogen. Data concerning the carcinogenicity of lead in humans are inconclusive. There is no evidence that oral exposure produces a tumor response. Although studies of occupational inhalation exposure have produced negative results, increases in cancer of the digestive organs and respiratory system have been reported (ATSDR, 1992h).

## Manganese

Most studies in humans and animals indicate that manganese exposure does not cause significant injury to the heart, stomach, blood, muscle, bone, liver, kidney, skin, or eyes However, if manganese is in the Mn (+7) valence state (as in potassium permanganate), then ingestion or dermal contact may lead to severe corrosion at the point of contact.

Inhalation exposure to manganese dusts often leads to an inflammatory response in lung in both humans and animals. This generally leads to increased incidence of cough and bronchitis, and can lead to mild to moderate injury to lung tissue, along with minor decreases in lung function. In addition, susceptibility to infectious lung disease may be increased, leading to increased prevalence of pneumonia.

Information on the carcinogenic potential of manganese is limited, and the results are difficult to interpret with certainty. Inhalation exposure of humans to manganese dusts has not been identified as a risk factor for lung cancer, although intraperitoneal injection of mice with manganese sulfate led to an increased incidence of lung tumors. Preliminary data indicate that chronic oral exposure of rats to manganese sulfate may lead to increased incidence of pancreatic tumors (adenomas plus carcinomas). These data are not adequate to reach a firm conclusion regarding the carcinogenicity of manganese, but suggest that the potential for carcinogenic effects in humans is small (ATSDR, 1991e).

## Mercury

Mercury and all compounds of mercury affect the central nervous system (CNS) and kidneys. Exposure to low levels over prolonged periods produces symptoms that can vary widely from individual to individual. These can include weakness, loss of appetite, weight loss, insomnia, indigestion, diarrhea, metallic taste in the mouth, increased salivation, mouth or throat soreness, inflammation of the gums, black line on the gums, loosening of teeth, irritability, loss of memory, and tremor in fingers, eyelids, lips, or tongue. Extensive exposure produces behavioral changes such as irritability, excitability, anxiety, delirium with hallucinations, melancholy, or manic depressive psychosis. This is known as erethism or Mad Hatter syndrome.

The target tissue for organic mercury effects is the central nervous system, especially the brain. Severe poisoning may produce irreversible brain damage resulting in loss of higher functions. The effects of chronic poisoning with alkyl mercury compounds are progressive. Initially there are fine tremors of the hands, and in some cases, of the face and arms. Tremors become coarse and convulsive, speech becomes moderately slurred and difficulty with pronunciation may occur with continued exposure. Development of an unsteady gait, can progress to severe ataxia of the arms and legs. Common sensory disturbances include tunnel vision, blindness, and deafness. A symptom that occurs later in exposure is the constriction of the visual field, which is rarely reversible and may be associated with loss of understanding and reason which makes the person completely out of touch with their environment.

There are no reliable human or animal studies which indicate that inhalation or oral exposure to mercury causes cancer (ATSDR, 1989b).

## Methylene Chloride

Methylene chloride has been widely used in industrial process, food preparation, agriculture, and consumer products; consequently, there have been numerous studies describing its effects in a variety of animal species. Humans have not been as extensively studied. Although its uses in agricultural goods and consumer products have declined in recent years, there is still potential public health concern due to its continued use in industrial processes and there have been releases to the environment.

The central nervous system (CNS) is a potential target in humans and animals at exposure levels of 800 ppm or higher. Effects have also been reported on the liver and kidney at concentrations of 25 ppm or greater and on the cardiovascular system, but at extremely high exposures. Methylene chloride (500 ppm or greater) increased tumors in some animals, but there were no teratogenic or reproductive effects. Since inhalation is the principal route of exposure to methylene chloride, most of these effects have been tested for or observed by this route. Data on effects observed after oral and dermal exposure are more limited.

Studies in animals exposed via inhalation have demonstrated that methylene chloride is probably carcinogenic. Concentrations of 500 ppm or greater increased the incidence of benign mammary gland tumors in female and male rats. The incidence of liver tumors increased over control levels in male mice and female rats administered methylene chloride (50 to 250 mg/kg/day) in drinking water; however, the incidence of lesions in treated groups were within the historical range of control values and showed no dose response relationship. Based on these findings, the EPA has ranked methylene chloride as a Group B2 carcinogen (probable human carcinogen) (ATSDR, 1992i).

## 2-, 3-, 4-Methylphenol (o-, p-, m-Cresol)

Effects associated with exposure to cresol in humans include irritation and burning of the skin, eyes, mouth, and throat, abdominal pain and vomiting, hemolytic anemia, kidney damage, facial paralysis, coma, and death. Studies in animals have documented the irritative and neurological effects of cresols, and provided some evidence for target organ effects on the kidney and the blood. Other effects seen in animals, but not observed in humans, include slightly reduced body weight gain, mild hepatotoxicity, mild developmental effects, and tumor promotion.

There are no data available regarding the carcinogenicity of exogenous cresols in humans. No cancer bioassays have been conducted in animals, but the results of a promotion study in mice suggested that cresols can be cancer promoters. The ability of cresols to interact with mammalian DNA in vitro suggests they may have carcinogenic potential, but it is impossible to assess the potential hazard to humans without more information (ATSDR, 1991d).

## Molybdenum

Molybdenum is an essential dietary nutrient which is a constituent of several mammalian enzymes including xanthine oxidase, sulfite oxidase and aldehyde oxidase. The Food and Nutrition Board of the Subcommittee on the Tenth Edition of the RDAs has established Estimated Safe and Adequate Daily Intake (ESAADI) values of 15-40 μg/day for infants, 25-150 μg/day for children, and 75-250 μg/day for adolescents and adults.

High levels of ingested molybdenum may be associated with mineral imbalance. Excretion of sufficient quantities of molybdenum may put individuals at risk for the hypochromic microcytic anemia associated with a dietary copper deficiency. Animal studies demonstrate that the effects of molybdenum on growth and melanin synthesis are more pronounced under situations where dietary copper intake is low. For this reason, the RfD was derived with the ESAADI in mind.

The RfD for molybdenum is based on the results of a study that examined blood chemistry parameters normally associated with gout. An exhaustive analysis of blood chemistry and individual dietary habits was not done. Therefore, the results are clearly generalized for a large population. Studies in humans and animals suggest that molybdenum has an adverse effect on copper homeostasis, making the changes in serum ceruloplasmin a matter of possible concern. The proposed RfD satisfies molybdenum nutrient requirements for all healthy members of the population, based on a comparison with the ESAADI. Dietary studies indicate that people in the U.S. are receiving between 76 and 240 μg/day (1.1-3.4 μg/kg-day, based on a 70 kg adult) in their diets.

There is no information that indicates that molybdenum is carcinogenic in humans (EPA, 1993).

In humans, acute exposure to nickel commonly results in contact dermatitis, atrophic dermatitis, and allergenic sensitization. Other signs and symptoms of exposure to nickel include nausea, vomiting, diarrhea, central nervous system depression, coughing, shortness of breath, chest pain, fever and weakness. Chronic occupational inhalation exposures may result in respiratory effects such as asthma and chronic respiratory tract infections. Nickel has not definitely been shown to be genotoxic or mutagenic. Studies have shown nickel to induce chromosomal aberrations in cultured mammalian cells and sister chromatid exchange in both mammalian cells and human lymphocytes, as well as the induction of morphological cell transformation in vitro. Ingested nickel may cause reproductive and developmental toxicity in animals. Reproductive effects in male rats include degenerative changes in the testes, epididymis and spermatozoa. Studies in female rats and hamsters suggest an effect on embryo viability and the implantation process. Animals exposed to nickel before implantation have shown delayed embryonic development and increased resorptions, although there are problems associated with the interpretation of these studies. Nickel may also be teratogenic.

Nickel is classified as a human carcinogen, in EPA Group A. Inhalation of nickel has been associated with lung and nasal cavity tumors in humans exposed to nickel refinery dusts. Evidence of carcinogenicity via inhalation is consistent in several epidemiologic studies from various countries. The findings are characterized by lung and nasal cancers, high relative risks, and a dose-response relationship by length of exposure. The nickel compounds which have been most strongly implicated as carcinogens are metallic nickel, nickel subsulfide, and nickel carbonyl (ATSDR, 1992j).

## Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic Aromatic Hydrocarbons (PAHs) are generally categorized into two groups: carcinogens and noncarcinogens. Those that have been shown to be carcinogenic to animals by the oral route are: benzo(a)anthracene, benzo(a)pyrene, and dibenzo(a,h)anthracene. Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene have been shown to be carcinogenic by the dermal route. For many of the carcinogenic PAHs, it would appear that the site of tumor induction is generally the point of first contact, i.e., stomach tumors are observed following ingestion, and skin tumors following dermal exposure.

Evidence exists to indicate that certain PAHs are carcinogenic in humans. PAHs express their carcinogenic activity through biotransformation to chemically reactive intermediates which then covalently bind to cellular macromolecules (i.e., DNA) leading to mutation and tumor initiation. The evidence of carcinogenicity in humans comes primarily from occupational studies where workers involved in such processes as coke production, roofing, oil refining or coal gasification are exposed to mixtures containing PAHs (e.g., coal tar, roofing tar, soot, coke oven emissions, soot, and crude oil). PAHs have not been clearly identified as the causative agent, however. Cancer associated with exposure to PAH-containing mixtures in humans occurs predominantly in the lung and skin following inhalation and dermal exposure, respectively. Some ingestion of PAHs is likely due to swallowing of particles containing PAHs subsequent to mucociliary clearance of these particulates from the lung.

Noncancer adverse health effects associated with noncarcinogenic PAHs (acenaphthene, acenanaphthylene, anthracene, fluoranthene, fluorene, phenanthrene,and pyrene) exposure have been observed in animals, but (with the exception of adverse hematological and dermal effects) generally not in humans. Animals studies demonstrate that PAHs tend to affect proliferating tissues such as bone marrow, lymphoid organs, gonads and intestinal epithelium. Thus, although PAHs are distributed extensively throughout the body, their major target organs appear to be the hematopoietic and lymphoid systems in animals.

The lymphoid system, because of its rapidly proliferating tissues, is susceptible to PAH-induced toxicity. The mechanism of action for this effect is most likely inhibition of DNA synthesis. No adverse effects on this system associated with PAH exposure have been reported in humans, but several accounts of lymphoid toxicity in animals were observed. Lymphoid effects in animals from PAH exposure include an increase in reticulum cells, accumulation of iron, reduced lymphoid cells, and dilated lymph sinuses.

The skin is susceptible to PAH-induced toxicity in humans. Regressive verrucae were reported following subchronic application of benzo(a)pyrene to human skin. Although reversible and apparently benign, these changes were seen to represent neoplastic

proliferation. Benzo(a)pyrene application also apparently exacerbated skin lesions in patients with pre-existing skin conditions (pemphigus vulgaris and xeroderma pigmentosum). Workers exposed to substances that contain PAHs (e.g., coal tar) experienced chronic dermatitis and hyperkeratosis.

Anthracene has been associated with gastrointestinal toxicity in humans. Humans that consumed laxatives that contained anthracene (anthracene concentration not specified) for prolonged periods were found to have an increased incidence (73.4%) of melanosis of the colon and rectum as compared to those who did not consume anthracene-containing laxatives (36.5%).

The developmental effects of PAHs, especially benzo(a) pyrene, have been investigated in animals using the parenteral route of administration. Injections of benzo(a)pyrene to pregnant mice produced stillbirths, resorptions, and malformations, testicular changes including atrophy of seminiferous tubules with lack of spermatoids and spermatozoa in males; immunosuppression; and tumor induction (ATSDR, 1990c).

## Tetrachloroethene

The major routes of exposure to tetrachloroethylene (perchloroethylene, PCE) are the inhalation and oral routes. The brain, liver, and kidney have been identified as target organs for adverse effects of PCE exposure. In addition, there is a suggestion that reproductive effects may also be induced in women. Humans exposed acutely to high concentrations of PCE had headache, dizziness, and drowsiness; nonspecific hepatotoxicity; reversible kidney damage; and upper respiratory tract irritation.

Some epidemiological studies of dry cleaning workers suggest a possible association between PCE exposure and increased cancer risk. However, the results of these studies are inconclusive because of the likelihood of concomitant exposure to other petroleum solvents, the effects of other confounding factors such as smoking, and the study methodology.

The carcinogenicity of PCE has been documented in animals exposed by inhalation or oral routes. Despite some indication of human risk of leukemia from solvent exposure, the relevance to human health of elevated incidences of cancer in laboratory animals is unclear. As of November 1992, EPA had not taken a final position on the weight-of-evidence classification for PCE (EPA, 1992). It is proposed for consideration as a Group B2 (probable human carcinogen) based on evidence of cancer in animals and equivocal evidence in humans (ATSDR, 1992k).

## Trichloroethene

The central nervous system (CNS) is the principal target for trichloroethene (TCE) toxicity in humans. Human experimental studies revealed mild effects on motor coordination, visual perception, and cognition. Nonspecific neurological effects from TCE exposure in the workplace are dizziness and drowsiness. Acute and chronic inhalation exposure, as well as chronic oral exposure have lead to dysfunction of cranial nerves V and VII. The available evidence suggests that humans may be at risk for neurological effects from exposure to TCE in the air and water, however, there is no information for the levels at which these effects might occur.

Workers who have been exposed to TCE in the workplace show no higher incidences of cancer than controls. This has been shown in numerous historical prospective studies. The few studies that did show some association were complicated by exposures to known human carcinogens.

Animal studies have shown increases in cancers of various types following inhalation or oral exposure to TCE. Due to various flaws in the study designs, the significance of these studies for humans cannot be determined. The EPA withdrew the IRIS carcinogenicity file for TCE in July 1989 and as of November 1992 has not adopted a current position on the weight-of-evidence classification (ATSDR, 19921; EPA, 1992).

## Vanadium

The only significant, clearly documented, effect of vanadium exposure in humans is mild to moderate respiratory distress and mucosal irritation from exposure to vanadium dusts. Vanadium workers may have coughs, chest pain, sore throats, or eye irritation, which can last for several days after exposure. These effects are common to many kinds of dust exposures. The effects are no more severe than those experienced during a routine upper respiratory tract infection and can sometimes be delayed for several hours after exposure. Chronic effects are not reported with regularity. Chest x-rays and urine and blood analyses in these people are normal. These workers often develop a green color on their tongues from direct accumulation of vanadium.

Studies in animals support the findings that vanadium primarily affects the respiratory system. The respiratory system responds to the particulate matter by increasing the number of leukocytes which are used to clear away the foreign matter.

A few animal studies have shown renal effects from parenteral injection of vanadium. These include increased lipid peroxidation and decreased tubular reabsorption. It is difficult to determine the potential for renal toxicity in humans exposed by normal exposure routes. Renal effects have not been observed upon urinanalysis in occupationally exposed workers.

Workers who have been exposed to vanadium dust did not show any large increases in cancer deaths, although detailed studies were not performed. Studies designed to test effects other than cancer in animals have not noted any increases in tumors resulting from inhalation or oral exposure to vanadium. To date, studies are inadequate to perform an acceptable assessment of the carcinogenic potential of vanadium. Vanadium has not been assigned a weight of evidence class for human carcinogenicity (ATSDR, 1991f).

## Vinyl Chloride

The effects that have been reported in humans in response to vinyl chloride exposure come almost exclusively from studies of workers exposed by inhalation in the workplace. Because women have not been traditionally employed in PVC-manufacturing positions in North America and Western Europe, most of the data on humans from these areas concerns effects in males. Also, virtually all of the epidemiological studies are limited by the absence of data on the actual levels to which workers were exposed. However, studies in animals by the inhalation and oral routes provide an indication of the doses of vinyl chloride that may be associated with these effects.

Acute high-level exposure of humans to vinyl chloride is associated with the development of signs of intoxication such as dizziness, drowsiness, and/or headache. Reports from vinyl chloride workers and studies in animals indicate that a loss of consciousness may also be associated with exposure to very high levels. Two deaths connected with occupational exposure to vinyl chloride have been reported. Autopsy results from these men as well as autopsy results from animals dying from extremely high-level exposures indicate that levels of vinyl chloride producing death may cause lung and kidney irritation and inhibition of blood clotting. Cardiac arrhythmias and liver degeneration have also been reported in animals as a result of acute exposure to very high levels of vinyl chloride.

Longer term exposure of humans in occupational settings has been associated with the development of a number of other toxic effects. However, exposure levels in these studies are generally not quantified, and thresholds for the effects have not been quantified. Histopathological changes characteristic of vinyl chloride exposure have been reported to take place in the liver. These changes include extensive fibrosis and hypertrophy and hyperplasia of both hepatocytes and sinusoidal cells. These changes in liver structure develop in the absence of overt symptoms of liver toxicity, and standard biochemical measures of liver function have been of little value in detecting them. Reports also indicate that peripheral neuropathy may also develop in some workers occupationally exposed to vinyl chloride. Also, toxic effects on male reproductive function may occur. Studies in animals indicate that vinyl chloride may cause fetal resorptions, delayed development, and an increased incidence of the soft tissue anomaly, dilated ureter. When animals were exposed in utero, some changes in liver function were observed during adolescence.

Studies in both humans and animals indicate that vinyl chloride is carcinogenic. Hepatic angiosarcoma has been identified in workers exposed to vinyl chloride by the inhalation route. Also, there are some studies that indicate that cancers of the central nervous system, respiratory tract, lymphatic and hematopoietic systems may occur in humans following inhalation exposure. Studies in a variety of animal species exposed by both inhalation and oral routes show an increased incidence of hepatic angiosarcoma. Based on these findings, the International Agency for Research on Cancer (IARC) has

concluded that sufficient evidence for carcinogenicity in humans and animals exists and has placed vinyl chloride in category 1, carcinogenic to humans. EPA has concluded that sufficient evidence for carcinogenicity exists in humans and animals and has classified vinyl chloride according to its classification scheme as a Group A carcinogen, human carcinogen (ATSDR, 1992m).

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# Appendix B

## Risk Calculations for Current Use Scenario

**Table B1**
**Equations and Example Calculations for Ingestion Exposure to Leachate**
**Bell Landfill Site**
**Towanda, Pennsylvania**

Equation Definition:

ADD = C x CR x ET x EF x ED / BW X AT

| Parameter | Definition |
|---|---|
| ADD | average daily dose |
| LADD | lifetime average daily dose |
| C | chemical concentration in water (mg/L) |
| CR | contact rate (L/hr) |
| ET | exposure time (hr/event) |
| EF | exposure frequency (events/yr) |
| ED | exposure duration (yr) |
| BW | body weight (kg) |
| AT | averaging time (70 yr for cancer risk; 10 yr for child trespasser, 30 yr for adult hunter for noncancer risk) |

Example Calculations (child trespasser exposed to arsenic)

Noncancer Risk

ADD = 0.0231 (mg/L) x 0.025 (L/hr) x 2 (hr/day) x 26 (d/yr) x 10 (yr) / 37 (kg) x 10 (yr) x 365 (d/yr)
ADD = 2.2E−6 (mg/kg/d)

Cancer Risk

LADD = ADD x ED / 70 (yr)
LADD = 2.2E−6 (mg/kg/d) x 10 (yr) / 70 (yr)
LADD = 3.2E−7 (mg/kg/d)

Source:
Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual (Part A) December 1989.

Table B2
Ingestion Exposure Doses and Risks for Child Trespasser Exposed to Leachate
Bell Landfill Site
Towanda, Pennsylvania

| Contaminant of Concern | RME (mg/L) | CR (L/hr) | ET (hr/d) | EF (d/yr) | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFo [(mg/kg/day)−1] | RfDo (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 0.0231 | 0.025 | 2 | 26 | 10 | 37 | 3650 | 2.2E−06 | 3.2E−07 | 1.75E+00 | 3E−04 | 6E−07 | 0.01 |
| Cadmium | 0.166 | 0.025 | 2 | 26 | 10 | 37 | 3650 | 1.6E−05 | 2.3E−06 | NA | 5E−04 | NA | 0.03 |
| Chromium | 0.227 | 0.025 | 2 | 26 | 10 | 37 | 3650 | 2.2E−05 | 3.1E−06 | NA | 5E−03 | NA | 0.004 |
| Cobalt | 1.44 | 0.025 | 2 | 26 | 10 | 37 | 3650 | 1.4E−04 | 2.0E−05 | NA | 6E−02 | NA | 0.002 |
| Manganese | 108 | 0.025 | 2 | 26 | 10 | 37 | 3650 | 1.0E−02 | 1.5E−03 | NA | 5E−03 | NA | 2.1 |
| Molybdenum | 1.8 | 0.025 | 2 | 26 | 10 | 37 | 3650 | 1.7E−04 | 2.5E−05 | NA | 5E−03 | NA | 0.03 |
| 1,2−Dichloroethene (total) | 0.59 | 0.025 | 2 | 26 | 10 | 37 | 3650 | 5.7E−05 | 8.1E−06 | NA | 1E−02 | NA | 0.01 |
| Acetone | 5.4 | 0.025 | 2 | 26 | 10 | 37 | 3650 | 5.2E−04 | 7.4E−05 | NA | 1E−01 | NA | 0.005 |
| Benzene | 0.013 | 0.025 | 2 | 26 | 10 | 37 | 3650 | 1.3E−06 | 1.8E−07 | 2.9E−02 | NA | 5E−09 | NA |
| Methylene Chloride | 28 | 0.025 | 2 | 26 | 10 | 37 | 3650 | 2.7E−03 | 3.9E−04 | 7.5E−03 | 6E−02 | 3E−06 | 0.04 |
| Toluene | 0.92 | 0.025 | 2 | 26 | 10 | 37 | 3650 | 8.9E−05 | 1.3E−05 | NA | 2E−01 | NA | 0.0004 |
| Trichloroethene | 0.35 | 0.025 | 2 | 26 | 10 | 37 | 3650 | 3.4E−05 | 4.8E−06 | 1.1E−02 | 6E−03 | 5E−08 | 0.01 |
| Vinyl Chloride | 0.044 | 0.025 | 2 | 26 | 10 | 37 | 3650 | 4.2E−06 | 6.1E−07 | 1.9E+00 | NA | 1E−06 | NA |
| Heptachlor epoxide | 0.000021 | 0.025 | 2 | 26 | 10 | 37 | 3650 | 2.0E−09 | 2.9E−10 | 9.1E+00 | 1.3E−05 | 3E−09 | 0.0002 |
| 4−Methylphenol | 3.8 | 0.025 | 2 | 26 | 10 | 37 | 3650 | 3.7E−04 | 5.2E−05 | NA | 5E−02 | NA | 0.01 |
| delta−BHC | 0.0047 | 0.025 | 2 | 26 | 10 | 37 | 3650 | 4.5E−07 | 6.5E−08 | 1.8E+00 | NA | 1E−07 | NA |

| | | | | | |
|---|---|---|---|---|---|
| RME Reasonable Maximum Exposure | BW Body Weight | RfDo Reference Dose (oral) | Total Route−Specific Risk | Cancer | HI |
| CR Contact Rate | AT Averaging Time | HQ Hazard Quotient | | | |
| ET Exposure Time | ADD Average Daily Dose | HI Hazard Index | | 5E−06 | 2.2 |
| EF Exposure Frequency | LADD Lifetime Average Daily Dose | ND Not Detected | | | |
| ED Exposure Duration | CSFo Cancer Slope Factor (oral) | NA Not Applicable | | | |

Table B3
Ingestion Exposure Doses and Risks for Adult Hunter Exposed to Leachate
Bell Landfill Site
Towanda, Pennsylvania

| Contaminant of Concern | RME (mg/L) | CR (L/hr) | ET (hrs/da | EF (days/ | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFo [(mg/kg/day)−1] | RfDo (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 0.0231 | 0.025 | 2 | 26 | 30 | 70 | 10950 | 1.2E−06 | 5.0E−07 | 1.75E+00 | 3E−04 | 9E−07 | 0.004 |
| Cadmium | 0.166 | 0.025 | 2 | 26 | 30 | 70 | 10950 | 8.4E−06 | 3.6E−06 | NA | 5E−04 | NA | 0.02 |
| Chromium | 0.227 | 0.025 | 2 | 26 | 30 | 70 | 10950 | 1.2E−05 | 4.9E−06 | NA | 5E−03 | NA | 0.002 |
| Cobalt | 1.44 | 0.025 | 2 | 26 | 30 | 70 | 10950 | 7.3E−05 | 3.1E−05 | NA | 6E−02 | NA | 0.001 |
| Manganese | 108 | 0.025 | 2 | 26 | 30 | 70 | 10950 | 5.5E−03 | 2.4E−03 | NA | 5E−03 | NA | 1.1 |
| Molybdenum | 1.8 | 0.025 | 2 | 26 | 30 | 70 | 10950 | 9.2E−05 | 3.9E−05 | NA | 5E−03 | NA | 0.02 |
| 1,2−Dichloroethene (total) | 0.59 | 0.025 | 2 | 26 | 30 | 70 | 10950 | 3.0E−05 | 1.3E−05 | NA | 1E−02 | NA | 0.003 |
| Acetone | 5.4 | 0.025 | 2 | 26 | 30 | 70 | 10950 | 2.7E−04 | 1.2E−04 | NA | 1E−01 | NA | 0.003 |
| Benzene | 0.013 | 0.025 | 2 | 26 | 30 | 70 | 10950 | 6.6E−07 | 2.8E−07 | 2.9E−02 | NA | 8E−09 | NA |
| Methylene Chloride | 28 | 0.025 | 2 | 26 | 30 | 70 | 10950 | 1.4E−03 | 6.1E−04 | 7.5E−03 | 6E−02 | 5E−06 | 0.02 |
| Toluene | 0.92 | 0.025 | 2 | 26 | 30 | 70 | 10950 | 4.7E−05 | 2.0E−05 | NA | 2E−01 | NA | 0.0002 |
| Trichloroethene | 0.35 | 0.025 | 2 | 26 | 30 | 70 | 10950 | 1.8E−05 | 7.6E−06 | 1.1E−02 | 6E−03 | 8E−08 | 0.003 |
| Vinyl Chloride | 0.044 | 0.025 | 2 | 26 | 30 | 70 | 10950 | 2.2E−06 | 9.6E−07 | 1.9E+00 | NA | 2E−06 | NA |
| Heptachlor epoxide | 0.000021 | 0.025 | 2 | 26 | 30 | 70 | 10950 | 1.1E−09 | 4.6E−10 | 9.1E+00 | 1.3E−05 | 4E−09 | 0.0001 |
| 4−Methylphenol | 3.8 | 0.025 | 2 | 26 | 30 | 70 | 10950 | 1.9E−04 | 8.3E−05 | NA | 5E−02 | NA | 0.004 |
| delta−BHC | 0.0047 | 0.025 | 2 | 26 | 30 | 70 | 10950 | 2.4E−07 | 1.0E−07 | 1.8E+00 | NA | 2E−07 | NA |

RME Reasonable Maximum Exposure
CR Contact Rate
ET Exposure Time
EF Exposure Frequency
ED Exposure Duration
BW Body Weight
AT Averaging Time
ADD Average Daily Dose
LADD Lifetime Average Daily Dose
CSFo Cancer Slope Factor (oral)
RfDo Reference Dose (oral)
HQ Hazard Quotient
HI Hazard Index
ND Not Detected
NA Not Applicable

| Total Route−Specific Risk | Cancer | HI |
|---|---|---|
| | 8E−06 | 1.2 |

**Table B4**
**Equations and Example Calculations for Dermal Exposure to Leachate**
**Bell Landfill Site**
**Towanda, Pennsylvania**

Equation Definition:

ADD = C x SA x PC x ET x EF x ED x CF / BW x AT

Parameter Definition

| | |
|---|---|
| ADD | average daily dose |
| LADD | lifetime average daily dose |
| C | chemical concentration in water (mg/L) |
| SA | skin surface area available for contact (cm2) |
| PC | dermal permeability constant (cm/hr) |
| ET | exposure time (hr/d) |
| EF | exposure frequency (d/yr) |
| ED | exposure duration (yr) |
| CF | volumetric conversion factor for water (1 L/1000 cm3) |
| BW | body weight (kg) |
| AT | averaging time (70 yr for cancer risk; 10 yr for child trespasser, 30 yr adult hunter for noncancer risk) |

Example Calculations (child trespasser exposed to arsenic)

Noncancer Risk

ADD = 0.0231 (mg/L) x 3560 (cm2) x 1.6E−4 (cm/hr) x 2 (hr/d) x 26 (d/yr) x 10 (yr) x 0.001 (L/cm3) /
37 (kg) x 10 (yr) x 365 (days/yr)
ADD = 5.1E−8 (mg/kg/d)

Cancer Risk

LADD = ADD x ED / 70(yr)
LADD = 5.1E−8 (mg/kg/d) x 10 (yr) / 70 (yr)
LADD = 7.2E−9 (mg/kg/d)

Toxicity values were adjusted from administered to absorbed dose as follows:

Examples: RfD(oral) for beryllium x 0.20 (default) = RfD(absorbed)
5E−3 (mg/kg/day) x 0.20 = 1E−3 (mg/kg/day)

CSF(oral) for beryllium / 0.20 (default) = CSF(absorbed)
4.3E+0 [(mg/kg/day)]−1 / 0.20 = 2.1E+1 [(mg/kg/day)]−1

Source:
Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual (Part A), December 1989.

**Table B5**
**Dermal Exposure Doses for Child Trespasser Exposed to Leachate**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | RME (mg/L) | SA (cm2) | PC (1) (cm/hr) | ET (hr/d) | EF (d/yr) | ED (yrs) | CF (L/cm3) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFd [(mg/kg/day) - 1] | RfDd (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 0.0231 | 3560 | 1.6E-04 | 2 | 26 | 10 | 0.001 | 37 | 3650 | 5.1E-08 | 7.2E-09 | 8.8E+00 | 6E-05 | 6E-08 | 0.001 |
| Cadmium | 0.166 | 3560 | 1.6E-04 | 2 | 26 | 10 | 0.001 | 37 | 3650 | 3.6E-07 | 5.2E-08 | NA | 1E-04 | NA | 0.004 |
| Chromium | 0.227 | 3560 | 1.6E-04 | 2 | 26 | 10 | 0.001 | 37 | 3650 | 5.0E-07 | 7.1E-08 | NA | 1E-03 | NA | 0.0005 |
| Cobalt | 1.44 | 3560 | 1.6E-04 | 2 | 26 | 10 | 0.001 | 37 | 3650 | 3.2E-06 | 4.5E-07 | NA | 1E-02 | NA | 0.0003 |
| Manganese | 108 | 3560 | 1.6E-04 | 2 | 26 | 10 | 0.001 | 37 | 3650 | 2.4E-04 | 3.4E-05 | NA | 1E-03 | NA | 0.2 |
| Molybdenum | 1.8 | 3560 | 1.6E-04 | 2 | 26 | 10 | 0.001 | 37 | 3650 | 3.9E-06 | 5.6E-07 | NA | 1E-03 | NA | 0.004 |
| 1,2-Dichloroethene (total) | 0.59 | 3560 | 1.0E-02 | 2 | 26 | 10 | 0.001 | 37 | 3650 | 8.1E-05 | 1.2E-05 | NA | 8E-03 | NA | 0.01 |
| Acetone | 5.4 | 3560 | 1.1E-03 | 2 | 26 | 10 | 0.001 | 37 | 3650 | 8.1E-05 | 1.2E-05 | NA | 8E-02 | NA | 0.001 |
| Benzene | 0.013 | 3560 | 2.1E-02 | 2 | 26 | 10 | 0.001 | 37 | 3650 | 3.7E-06 | 5.3E-07 | 3.6E-02 | NA | 2E-08 | NA |
| Methylene Chloride | 28 | 3560 | 4.5E-03 | 2 | 26 | 10 | 0.001 | 37 | 3650 | 1.7E-03 | 2.5E-04 | 9.4E-03 | 5E-02 | 2E-06 | 0.04 |
| Toluene | 0.92 | 3560 | 4.5E-02 | 2 | 26 | 10 | 0.001 | 37 | 3650 | 5.7E-04 | 8.1E-05 | NA | 2E-01 | NA | 0.003 |
| Trichloroethene | 0.35 | 3560 | 1.6E-02 | 2 | 26 | 10 | 0.001 | 37 | 3650 | 7.7E-05 | 1.1E-05 | 1.4E-02 | 5E-03 | 2E-07 | 0.02 |
| Vinyl Chloride | 0.044 | 3560 | 7.3E-03 | 2 | 26 | 10 | 0.001 | 37 | 3650 | 4.4E-06 | 6.3E-07 | 2.4E+00 | NA | 1E-06 | NA |
| Heptachlor epoxide | 0.000021 | 3560 | 1.1E-02 | 2 | 26 | 10 | 0.001 | 37 | 3650 | 3.2E-09 | 4.5E-10 | 1.8E+01 | 7E-06 | 8E-09 | 0.0005 |
| 4-Methylphenol | 3.8 | 3560 | 1.0E-02 | 2 | 26 | 10 | 0.001 | 37 | 3650 | 5.2E-04 | 7.4E-05 | NA | 3E-02 | NA | 0.02 |
| delta-BHC | 0.0047 | 3560 | 1.4E-02 | 2 | 26 | 10 | 0.001 | 37 | 3650 | 9.0E-07 | 1.3E-07 | 3.6E+00 | NA | 5E-07 | NA |

RME Reasonable Maximum Exposure
SA Skin Surface Area
PC Dermal Permeability Constant
ET Exposure Time
EF Exposure Frequency
ED Exposure Duration

CF Volumetric Conversion Factor
BW Body Weight
AT Averaging Time
ADD Average Daily Dose
LADD Lifetime Average Daily Dose
CSFd Cancer Slope Factor (dermal)

RfDd Reference Dose (dermal)
HQ Hazard Quotient
HI Hazard Index
ND Not Detected
NA Not Applicable

| Total Route-Specific Risk | Cancer | HI |
|---|---|---|
| | 5E-06 | 0.3 |

Note: (1) Permeability Constant for water used as conservative estimate for inorganics

**Table B6**
**Dermal Exposure Doses for Adult Hunter Exposed to Leachate**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | RME (mg/L) | SA (cm2) | PC (1) (cm/hr) | ET (hr/d) | EF (d/yr) | ED (yrs) | CF (L/cm3) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFd [(mg/kg/day)-1] | RfDd (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 0.0231 | 8620 | 1.6E-04 | 2 | 26 | 30 | 0.001 | 70 | 10950 | 6.5E-08 | 2.8E-08 | 8.8E+00 | 6E-05 | 2E-07 | 0.001 |
| Cadmium | 0.166 | 8620 | 1.6E-04 | 2 | 26 | 30 | 0.001 | 70 | 10950 | 4.7E-07 | 2.0E-07 | NA | 1E-04 | NA | 0.005 |
| Chromium | 0.227 | 8620 | 1.6E-04 | 2 | 26 | 30 | 0.001 | 70 | 10950 | 6.4E-07 | 2.7E-07 | NA | 1E-03 | NA | 0.001 |
| Cobalt | 1.44 | 8620 | 1.6E-04 | 2 | 26 | 30 | 0.001 | 70 | 10950 | 4.0E-06 | 1.7E-06 | NA | 1E-02 | NA | 0.0004 |
| Manganese | 108 | 8620 | 1.6E-04 | 2 | 26 | 30 | 0.001 | 70 | 10950 | 3.0E-04 | 1.3E-04 | NA | 1E-03 | NA | 0.3 |
| Molybdenum | 1.8 | 8620 | 1.6E-04 | 2 | 26 | 30 | 0.001 | 70 | 10950 | 5.1E-06 | 2.2E-06 | NA | 1E-03 | NA | 0.005 |
| 1,2-Dichloroethene (total) | 0.59 | 8620 | 1.0E-02 | 2 | 26 | 30 | 0.001 | 70 | 10950 | 1.0E-04 | 4.4E-05 | NA | 8E-03 | NA | 0.01 |
| Acetone | 5.4 | 8620 | 1.1E-03 | 2 | 26 | 30 | 0.001 | 70 | 10950 | 1.0E-04 | 4.5E-05 | NA | 8E-02 | NA | 0.001 |
| Benzene | 0.013 | 8620 | 2.1E-02 | 2 | 26 | 30 | 0.001 | 70 | 10950 | 4.8E-06 | 2.1E-06 | 3.6E-02 | NA | 7E-08 | NA |
| Methylene Chloride | 28 | 8620 | 4.5E-03 | 2 | 26 | 30 | 0.001 | 70 | 10950 | 2.2E-03 | 9.5E-04 | 9.4E-03 | 5E-02 | 9E-06 | 0.05 |
| Toluene | 0.92 | 8620 | 4.5E-02 | 2 | 26 | 30 | 0.001 | 70 | 10950 | 7.3E-04 | 3.1E-04 | NA | 2E-01 | NA | 0.004 |
| Trichloroethene | 0.35 | 8620 | 1.6E-02 | 2 | 26 | 30 | 0.001 | 70 | 10950 | 9.8E-05 | 4.2E-05 | 1.4E-02 | 5E-03 | 6E-07 | 0.02 |
| Vinyl Chloride | 0.044 | 8620 | 7.3E-03 | 2 | 26 | 30 | 0.001 | 70 | 10950 | 5.6E-06 | 2.4E-06 | 2.4E+00 | NA | 6E-06 | NA |
| Heptachlor epoxide | 0.000021 | 8620 | 1.1E-02 | 2 | 26 | 30 | 0.001 | 70 | 10950 | 4.1E-09 | 1.7E-09 | 1.8E+01 | 7E-06 | 3E-08 | 0.001 |
| 4-Methylphenol | 3.8 | 8620 | 1.0E-02 | 2 | 26 | 30 | 0.001 | 70 | 10950 | 6.7E-04 | 2.9E-04 | NA | 3E-02 | NA | 0.03 |
| delta-BHC | 0.0047 | 8620 | 1.4E-02 | 2 | 26 | 30 | 0.001 | 70 | 10950 | 1.2E-06 | 4.9E-07 | 3.6E+00 | NA | 2E-06 | NA |

RME Reasonable Maximum Exposure
SA Skin Surface Area
PC Dermal Permeability Constant
ET Exposure Time
EF Exposure Frequency
ED Exposure Duration
CF Volumetric Conversion Factor
BW Body Weight
AT Averaging Time
ADD Average Daily Dose
LADD Lifetime Average Daily Dose
CSFd Cancer Slope Factor (dermal)
RfDd Reference Dose (dermal)
HQ Hazard Quotient
HI Hazard Index
ND Not Detected
NA Not Applicable

| Total Route-Specific Risk | Cancer | HI |
|---|---|---|
| | 2E-05 | 0.4 |

Note: (1) Permeability Constant for water used as conservative estimate for inorganics

**Table B7**
**Equations and Example Calculations for Ingestion Exposure to Soil or Sediment**
**Bell Landfill Site**
**Towanda, Pennsylvania**

Equation Definition:

ADD = C x IR x CF x FI x EF x ED / BW x AT

Parameter Definition

| | |
|---|---|
| ADD | average daily dose |
| LADD | lifetime average daily dose |
| C | chemical concentration in soil (mg/kg) |
| IR | ingestion rate (mg soil per day) |
| CF | conversion factor (kg/mg) |
| FI | fraction ingested from contaminated source (unitless) |
| EF | exposure frequency (days/year) |
| ED | exposure duration (years) |
| BW | body weight (kg) |
| AT | averaging time (70 yr for cancer risk; 10 yr for child trespasser, 30 yr for adult hunter, 6 yr for child resident, and 25 yr for adult worker for noncancer risk) |

Example Calculations (child trespasser exposed to arsenic)

Noncancer Risk

ADD = 11.4 (mg/kg) x 100 (mg/day) x 1E−6 (kg/mg) x 1.0 x 26 (days/yr) x 10 (yrs) /
37 (kg) x 10 (yrs) x 365 (days/yr)
ADD = 2.2E−6 (mg/kg/day)

Cancer Risk

LADD = ADD x ED / 70 (yr)
LADD = 2.2E−6 (mg/kg/d) x 10 (yr) / 70 (yr)
LADD = 3.1E−7 (mg/kg/d)

Source:
Risk Assessment Guidance for Superfund: Human Health Evaluation Manual (Part A), December 1989.

Table B8
Ingestion Exposure Doses and Risks for Child Trespasser Exposed to Soil
Bell Landfill Site
Towanda, Pennsylvania

| Contaminant of Concern | RME (mg/kg) | IR (mg/d) | CF (kg/mg) | FI | EF (d/yr) | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/d) | LADD (mg/kg/d) | CSFo [(mg/kg/d)]−1 | RfDo (mg/kg/d) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 11.4 | 100 | 1E−06 | 1 | 26 | 10 | 37 | 3650 | 2.2E−06 | 3.1E−07 | 1.75E+00 | 3E−04 | 5E−07 | 0.01 |
| Barium | 354 | 100 | 1E−06 | 1 | 26 | 10 | 37 | 3650 | 6.8E−05 | 9.7E−06 | NA | 7E−02 | NA | 0.001 |
| Beryllium | 0.55 | 100 | 1E−06 | 1 | 26 | 10 | 37 | 3650 | 1.1E−07 | 1.5E−08 | 4.3E+00 | 5E−03 | 7E−08 | 0.00002 |
| Cadmium | 134 | 100 | 1E−06 | 1 | 26 | 10 | 37 | 3650 | 2.6E−05 | 3.7E−06 | NA | 5E−04 | NA | 0.05 |
| Chromium | 30 | 100 | 1E−06 | 1 | 26 | 10 | 37 | 3650 | 5.8E−06 | 8.3E−07 | NA | 5E−03 | NA | 0.001 |
| Lead | 3166 | 100 | 1E−06 | 1 | 26 | 10 | 37 | 3650 | 6.1E−04 | 8.7E−05 | NA | NA | NA | NA |
| Manganese | 10100 | 100 | 1E−06 | 1 | 26 | 10 | 37 | 3650 | 1.9E−03 | 2.8E−04 | NA | 1E−01 | NA | 0.01 |
| Mercury | 1 | 100 | 1E−06 | 1 | 26 | 10 | 37 | 3650 | 1.9E−07 | 2.8E−08 | NA | 3E−04 | NA | 0.001 |
| Benzo(a)pyrene | 0.12 | 100 | 1E−06 | 1 | 26 | 10 | 37 | 3650 | 2.3E−08 | 3.3E−09 | 7.3E+00 | NA | 2E−08 | NA |

RME Reasonable Maximum Exposure
IR Ingestion Rate
CF Conversion Factor
FI Fraction Ingested
EF Exposure Frequency
ED Exposure Duration
BW Body Weight
AT Averaging Time
ADD Average Daily Dose
LADD Lifetime Average Daily Dose
CSFo Cancer Slope Factor (oral)
RfDo Reference Dose (oral)
HQ Hazard Quotient
HI Hazard Index
NA Not Applicable

| Total Route−Specific Risk | Cancer | HI |
|---|---|---|
| | 6E−07 | 0.1 |

**Table B9**
**Ingestion Exposure Doses and Risks for Adult Hunter Exposed to Soil**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | RME (mg/kg) | IR (mg/d) | CF (kg/mg) | FI | EF (d/yr) | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/d) | LADD (mg/kg/d) | CSFo [(mg/kg/d)]−1 | RfDo (mg/kg/d) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 11.4 | 50 | 1E−06 | 1 | 26 | 30 | 70 | 10950 | 5.8E−07 | 2.5E−07 | 1.75E+00 | 3E−04 | 4E−07 | 0.002 |
| Barium | 354 | 50 | 1E−06 | 1 | 26 | 30 | 70 | 10950 | 1.8E−05 | 7.7E−06 | NA | 7E−02 | NA | 0.0003 |
| Beryllium | 0.55 | 50 | 1E−06 | 1 | 26 | 30 | 70 | 10950 | 2.8E−08 | 1.2E−08 | 4.3E+00 | 5E−03 | 5E−08 | 0.00001 |
| Cadmium | 134 | 50 | 1E−06 | 1 | 26 | 30 | 70 | 10950 | 6.8E−06 | 2.9E−06 | NA | 5E−04 | NA | 0.01 |
| Chromium | 30 | 50 | 1E−06 | 1 | 26 | 30 | 70 | 10950 | 1.5E−06 | 6.5E−07 | NA | 5E−03 | NA | 0.0003 |
| Lead | 3166 | 50 | 1E−06 | 1 | 26 | 30 | 70 | 10950 | 1.6E−04 | 6.9E−05 | NA | NA | NA | NA |
| Manganese | 10100 | 50 | 1E−06 | 1 | 26 | 30 | 70 | 10950 | 5.1E−04 | 2.2E−04 | NA | 1E−01 | NA | 0.004 |
| Mercury | 1 | 50 | 1E−06 | 1 | 26 | 30 | 70 | 10950 | 5.1E−08 | 2.2E−08 | NA | 3E−04 | NA | 0.0002 |
| Benzo(a)pyrene | 0.12 | 50 | 1E−06 | 1 | 26 | 30 | 70 | 10950 | 6.1E−09 | 2.6E−09 | 7.3E+00 | NA | 2E−08 | NA |

RME Reasonable Maximum Exposure
IR Ingestion Rate
CF Conversion Factor
FI Fraction Ingested
EF Exposure Frequency
ED Exposure Duration
BW Body Weight
AT Averaging Time
ADD Average Daily Dose
LADD Lifetime Average Daily Dose
CSFo Cancer Slope Factor (oral)
RfDo Reference Dose (oral)
HQ Hazard Quotient
HI Hazard Index
NA Not Applicable

| Total Route−Specific Risk | Cancer | HI |
|---|---|---|
| | 5E−07 | 0.02 |

**Table B10**
**Equations and Example Calculations for Inhalation Exposure to Particulates**
**Bell Landfill Site**
**Towanda, Pennsylvania**

Equation Definition:

ADD = C x ED x EF x IR x (1/PEF) / BW x AT

| Parameter | Definition |
|---|---|
| ADD | average daily dose |
| LADD | lifetime average daily dose |
| C | chemical concentration in soil (mg/kg) |
| ED | exposure duration (yr) |
| EF | exposure frequency (d/yr) |
| IR | inhalation rate (m3/d) |
| PEF | particulate emissions factor (m3/kg) |
| BW | body weight (kg) |
| AT | averaging time (70 yr for cancer risk; 10 yr for child trespasser, 30 yr for adult hunter, 6 yr for child resident, 25 yr for adult worker for noncancer risk) |

Example Calculations (child trespasser exposed to arsenic)

Noncancer Risk

ADD = 11.4 (mg/kg) x 10 (yr) x 26 (d/yr) x 20 (m3/d) x (1/4.63E+9 m3/kg) / 37 (kg) x 10 (yr) x 365 (d/yr)
ADD = 9.5E−11 (mg/kg/d)

Cancer Risk

LADD = ADD x ED / 70 (yr)
LADD = 9.5E−11 (mg/kg/d) x 10 (yr) / 70 (yr)
LADD = 1.4E−11 (mg/kg/d)

Source:
Human Health Evaluation Manual, Part B, Development of Risk−based Preliminary Remediation Goals, December 1991.

Table B11
Inhalation Exposure Doses and Risks for Child Trespasser Exposed to Soil
Bell Landfill Site
Towanda, Pennsylvania

| Contaminant of Concern | RME (mg/kg) | ED (yrs) | EF (d/yr) | IR (m3/d) | PEF (m3/kg) | BW (kg) | AT (days) | ADD (mg/kg/d) | LADD (mg/kg/d) | CSFI [(mg/kg/d)]-1 | RfDi (mg/kg/d) | Cancer | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 11.4 | 10 | 26 | 20 | 4.63E+09 | 37 | 3650 | 9.5E-11 | 1.4E-11 | 1.5E+01 | NA | 2E-10 | NA |
| Barium | 354 | 10 | 26 | 20 | 4.63E+09 | 37 | 3650 | 2.9E-09 | 4.2E-10 | NA | NA | NA | NA |
| Beryllium | 0.55 | 10 | 26 | 20 | 4.63E+09 | 37 | 3650 | 4.6E-12 | 6.6E-13 | 8.4E+00 | NA | 6E-12 | NA |
| Cadmium | 134 | 10 | 26 | 20 | 4.63E+09 | 37 | 3650 | 1.1E-09 | 1.6E-10 | 6.3E+00 | NA | 1E-09 | NA |
| Chromium | 30 | 10 | 26 | 20 | 4.63E+09 | 37 | 3650 | 2.5E-10 | 3.6E-11 | 4.2E+01 | NA | 1E-09 | NA |
| Lead | 3166 | 10 | 26 | 20 | 4.63E+09 | 37 | 3650 | 2.6E-08 | 3.8E-09 | NA | NA | NA | NA |
| Manganese | 10100 | 10 | 26 | 20 | 4.63E+09 | 37 | 3650 | 8.4E-08 | 1.2E-08 | NA | NA | NA | NA |
| Mercury | 1 | 10 | 26 | 20 | 4.63E+09 | 37 | 3650 | 8.3E-12 | 1.2E-12 | NA | 8.6E-05 | NA | 0.0000001 |
| Benzo(a)pyrene | 0.12 | 10 | 26 | 20 | 4.63E+09 | 37 | 3650 | 1.0E-12 | 1.4E-13 | NA | NA | NA | NA |

RME Reasonable Max Exposure
ED Exposure Duration
EF Exposure Frequency
IR Inhalation Rate
PEF Particulate Emissions Factor
BW Body Weight
Averaging Time
ADD Average Daily Dose
LADD Lifetime Average Daily Dose
CSFi Cancer Slope Factor (inhalation)
RfDi Reference Dose (inhalation)
HQ Hazard Quotient
HI Hazard Index
NA Not Applicable

| Total Route-Specific Risk | Cancer | HI |
|---|---|---|
| | 3E-09 | 0.0000001 |

Table B12
Inhalation Exposure Doses and Risks for Adult Hunter Exposed to Soil
Bell Landfill Site
Towanda, Pennsylvania

| Contaminant of Concern | RME (mg/kg) | ED (yrs) | EF (d/yr) | IR (m3/d) | PEF (m3/kg) | BW (kg) | AT (days) | ADD (mg/kg/d) | LADD (mg/kg/d) | CSFI [(mg/kg/d)]−1 | RfDi (mg/kg/d) | Cancer | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 11.4 | 30 | 26 | 20 | 4.63E+09 | 70 | 10950 | 5.0E−11 | 2.1E−11 | 1.5E+01 | NA | 3E−10 | NA |
| Barium | 354 | 30 | 26 | 20 | 4.63E+09 | 70 | 10950 | 1.6E−09 | 6.7E−10 | NA | NA | NA | NA |
| Beryllium | 0.55 | 30 | 26 | 20 | 4.63E+09 | 70 | 10950 | 2.4E−12 | 1.0E−12 | 8.4E+00 | NA | 9E−12 | NA |
| Cadmium | 134 | 30 | 26 | 20 | 4.63E+09 | 70 | 10950 | 5.9E−10 | 2.5E−10 | 6.3E+00 | NA | 2E−09 | NA |
| Chromium | 30 | 30 | 26 | 20 | 4.63E+09 | 70 | 10950 | 1.3E−10 | 5.7E−11 | 4.2E+01 | NA | 2E−09 | NA |
| Lead | 3166 | 30 | 26 | 20 | 4.63E+09 | 70 | 10950 | 1.4E−08 | 6.0E−09 | NA | NA | NA | NA |
| Manganese | 10100 | 30 | 26 | 20 | 4.63E+09 | 70 | 10950 | 4.4E−08 | 1.9E−08 | NA | NA | NA | NA |
| Mercury | 1 | 30 | 26 | 20 | 4.63E+09 | 70 | 10950 | 4.4E−12 | 1.9E−12 | NA | 8.6E−05 | NA | 0.0000001 |
| Benzo(a)pyrene | 0.12 | 30 | 26 | 20 | 4.63E+09 | 70 | 10950 | 5.3E−13 | 2.3E−13 | NA | NA | NA | NA |

RME Reasonable Max Exposure
ED Exposure Duration
EF Exposure Frequency
IR Inhalation Rate
PEF Particulate Emissions Factor
BW Body Weight
Averaging Time
ADD Average Daily Dose
LADD Lifetime Average Daily Dose
CSFI Cancer Slope Factor (inhalation)
RfDi Reference Dose (inhalation)
HQ Hazard Quotient
HI Hazard Index
NA Not Applicable

| Total Route−Specific Risk | Cancer | HI |
|---|---|---|
| | 4E−09 | 0.0000001 |

**Table B13**
**Equations and Example Calculations for Ingestion Exposure to Groundwater**
**Bell Landfill Site**
**Towanda, Pennsylvania**

Equation Definition:

ADD = C x IR x EF x ED x CF / BW x AT

| Parameter | Definition |
|---|---|
| ADD | average daily dose |
| LADD | lifetime average daily dose |
| C | chemical concentration in water (ug/L) |
| IR | ingestion rate (L/d) |
| EF | exposure frequency (d/yr) |
| ED | exposure duration (yr) |
| BW | body weight (kg) |
| AT | averaging time (70 yr for cancer risk; 6 yr for child resident, 24 or 30 yr adult resident, 25 yr adult worker for noncancer risk) |
| CF | conversion factor (mg/ug) |

Example Calculations (child resident "C" exposed to arsenic)

Noncancer Risk

ADD = 1.2 (ug/L) x 1 (L/d) x 0.001 (mg/ug) x 350 (d/yr) x 6 (yr) / 70 (kg) x 6 (yr) x 365 (d/yr)
ADD = 7.7E−5 (mg/kg/d)

Cancer Risk

LADD = ADD x ED / 70(yr)
LADD = 7.7E−5 (mg/kg/d) x 6 (yr) / 70(yr)
LADD = 6.6E−6 (mg/kg/d)

Source:
Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual (Part A), December 1989.

**Table B14**
**Ingestion Exposure Doses and Risks for Resident C Child Exposed to Groundwater**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | RME (ug/L) | IR (L/d) | CF (mg/ug) | EF (d/yr) | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFo (mg/kg/day)-1 | RfDo (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 1.2 | 1 | 0.001 | 350 | 6 | 15 | 2190 | 7.7E-05 | 6.6E-06 | 1.75E+00 | 3.0E-04 | 1E-05 | 0.3 |
| Bis(2-Ethylhexyl)phthalate | 21 | 1 | 0.001 | 350 | 6 | 15 | 2190 | 1.3E-03 | 1.2E-04 | 1.4E-02 | 2.0E-02 | 2E-06 | 0.1 |

| | | | | Cancer | HI |
|---|---|---|---|---|---|
| RME Reasonable Max Exp | BW Body Weight | RfDo Reference Dose (oral) | Total Route-Specific Risk | | |
| IR Ingestion Rate | AT Averaging Time | HQ Hazard Quotient | | | |
| CF Conversion Factor | ADD Average Daily Dose | HI Hazard Index | | 1E-05 | 0.3 |
| EF Exposure Frequency | Lifetime Average Daily Dose | ND Not Detected | | | |
| ED Exposure Duration | CSFo Cancer Slope Factor (oral) | NA Not Applicable | | | |

**Table B15**
**Ingestion Exposure Doses and Risks for Resident C 24–yrAdult Exposed to Groundwater**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | RME (ug/L) | IR (L/day) | CF (mg/ug) | EF (d/yr) | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFo (mg/kg/day)–1 | RfDo (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 1.2 | 2 | 0.001 | 350 | 24 | 70 | 8760 | 3.3E–05 | 1.1E–05 | 1.75E+00 | 3.0E–04 | 2E–05 | 0.1 |
| Bis(2–Ethylhexyl)phthalate | 21 | 2 | 0.001 | 350 | 24 | 70 | 8760 | 5.8E–04 | 2.0E–04 | 1.4E–02 | 2.0E–02 | 3E–06 | 0.03 |

RME Reasonable Max Exp
IR Ingestion Rate
CF Conversion Factor
EF Exposure Frequency
ED Exposure Duration
BW Body Weight
AT Averaging Time
ADD Average Daily Dose
Lifetime Average Daily Dose
CSFo Cancer Slope Factor (oral)
RfDo Reference Dose (oral)
HQ Hazard Quotient
HI Hazard Index
ND Not Detected
NA Not Applicable

| Total Route–Specific Risk | Cancer | HI |
|---|---|---|
| | 2E–05 | 0.1 |

**Table B16**
**Ingestion Exposure Doses and Risks for Resident C 30–yr Adult Exposed to Groundwater**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | RME (ug/L) | IR (L/day) | CF (mg/ug) | EF (d/yr) | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFo (mg/kg/day)–1 | RfDo (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 1.2 | 2 | 0.001 | 350 | 30 | 70 | 10950 | 3.3E–05 | 1.4E–05 | 1.75E+00 | 3.0E–04 | 2E–05 | 0.1 |
| Bis(2–Ethylhexyl)phthalate | 21 | 2 | 0.001 | 350 | 30 | 70 | 10950 | 5.8E–04 | 2.5E–04 | 1.4E–02 | 2.0E–02 | 3E–06 | 0.03 |

| | | | | | |
|---|---|---|---|---|---|
| RME Reasonable Max Exp | BW Body Weight | RfDo Reference Dose (oral) | Total Route–Specific Risk | Cancer | HI |
| IR Ingestion Rate | AT Averaging Time | HQ Hazard Quotient | | | |
| CF Conversion Factor | ADD Average Daily Dose | HI Hazard Index | | 3E–05 | 0.1 |
| EF Exposure Frequency | Lifetime Average Daily Dose | ND Not Detected | | | |
| ED Exposure Duration | CSFo Cancer Slope Factor (oral) | NA Not Applicable | | | |

Table B17
Ingestion Exposure Doses and Risks for Resident D Child Exposed to Groundwater
Bell Landfill Site
Towanda, Pennsylvania

| Contaminant of Concern | RME (ug/L) | IR (L/day) | CF (mg/ug) | EF (d/yr) | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFo (mg/kg/day)-1 | RfDo (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 2.6 | 1 | 0.001 | 350 | 6 | 15 | 2190 | 1.7E-04 | 1.4E-05 | 1.75E+00 | 3.0E-04 | 2E-05 | 0.6 |

RME Reasonable Max Exp
IR Ingestion Rate
CF Conversion Factor
EF Exposure Frequency
ED Exposure Duration

BW Body Weight
AT Averaging Time
ADD Average Daily Dose
Lifetime Average Daily Dose
CSFo Cancer Slope Factor (oral)

RfDo Reference Dose (oral)
HQ Hazard Quotient
HI Hazard Index
ND Not Detected
NA Not Applicable

| Total Route-Specific Risk | Cancer | HI |
|---|---|---|
| | 2E-05 | 0.6 |

**Table B18**
**Ingestion Exposure Doses and Risks for Resident D 24–yr Adult Exposed to Groundwater**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | RME (ug/L) | IR (L/day) | CF (mg/ug) | EF (d/yr) | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFo (mg/kg/day)–1 | RfDo (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 2.6 | 2 | 0.001 | 350 | 24 | 70 | 8760 | 7.1E–05 | 2.4E–05 | 1.75E+00 | 3.0E–04 | 4E–05 | 0.2 |

RME Reasonable Max Exp
IR Ingestion Rate
CF Conversion Factor
EF Exposure Frequency
ED Exposure Duration
BW Body Weight
AT Averaging Time
ADD Average Daily Dose
Lifetime Average Daily Dose
CSFo Cancer Slope Factor (oral)
RfDo Reference Dose (oral)
HQ Hazard Quotient
HI Hazard Index
ND Not Detected
NA Not Applicable

| Total Route–Specific Risk | Cancer | HI |
|---|---|---|
| | 4E–05 | 0.2 |

Table B19
Ingestion Exposure Doses and Risks for Resident D 30–yr Adult Exposed to Groundwater
Bell Landfill Site
Towanda, Pennsylvania

| Contaminant of Concern | RME (ug/L) | IR (L/day) | CF (mg/ug) | EF (d/yr) | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFo (mg/kg/day)–1 | RfDo (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 2.6 | 2 | 0.001 | 350 | 30 | 70 | 10950 | 7.1E–05 | 3.1E–05 | 1.75E+00 | 3.0E–04 | 5E–05 | 0.2 |

RME Reasonable Max Exp
IR Ingestion Rate
CF Conversion Factor
EF Exposure Frequency
ED Exposure Duration
BW Body Weight
AT Averaging Time
ADD Average Daily Dose
Lifetime Average Daily Dose
CSFo Cancer Slope Factor (oral)
RfDo Reference Dose (oral)
HQ Hazard Quotient
HI Hazard Index
ND Not Detected
NA Not Applicable

| Total Route–Specific Risk | Cancer | HI |
|---|---|---|
| | 5E–05 | 0.2 |

Table B20
Ingestion Exposure Doses and Risks for Resident F Child Exposed to Groundwater
Bell Landfill Site
Towanda, Pennsylvania

| Contaminant of Concern | RME (ug/L) | IR (L/day) | CF (mg/ug) | EF (d/yr) | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFo (mg/kg/day)−1 | RfDo (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Manganese | 54 | 1 | 0.001 | 350 | 6 | 15 | 2190 | 3.5E−03 | 3.0E−04 | NA | 5E−03 | NA | 0.7 |

| | Cancer | HI |
|---|---|---|
| Total Route−Specific Risk | NA | 0.7 |

RME Reasonable Max Exp
IR Ingestion Rate
CF Conversion Factor
EF Exposure Frequency
ED Exposure Duration

BW Body Weight
AT Averaging Time
ADD Average Daily Dose
Lifetime Average Daily Dose
CSFo Cancer Slope Factor (oral)

RfDo Reference Dose (oral)
HQ Hazard Quotient
HI Hazard Index
ND Not Detected
NA Not Applicable

Table B21
Ingestion Exposure Doses and Risks for Resident F 24-yr Adult Exposed to Groundwater
Bell Landfill Site
Towanda, Pennsylvania

| Contaminant of Concern | RME (ug/L) | IR (L/day) | CF (mg/ug) | EF (d/yr) | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFo (mg/kg/day)-1 | RfDo (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Manganese | 54 | 2 | 0.001 | 350 | 24 | 70 | 8760 | 1.5E-03 | 5.1E-04 | NA | 5E-03 | NA | 0.3 |

RME Reasonable Max Exp
IR Ingestion Rate
CF Conversion Factor
EF Exposure Frequency
ED Exposure Duration
BW Body Weight
AT Averaging Time
ADD Average Daily Dose
Lifetime Average Daily Dose
CSFo Cancer Slope Factor (oral)
RfDo Reference Dose (oral)
HQ Hazard Quotient
HI Hazard Index
ND Not Detected
NA Not Applicable

| Total Route-Specific Risk | Cancer | HI |
|---|---|---|
| | NA | 0.3 |

Table B22
Ingestion Exposure Doses and Risks for Resident F 30–yr Adult Exposed to Groundwater
Bell Landfill Site
Towanda, Pennsylvania

| Contaminant of Concern | RME (ug/L) | IR (L/day) | CF (mg/ug) | EF (d/yr) | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFo (mg/kg/day)–1 | RfDo (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Manganese | 54 | 2 | 0.001 | 350 | 30 | 70 | 10950 | 1.5E–03 | 6.3E–04 | NA | 5E–03 | NA | 0.3 |

RME Reasonable Max Exp
IR Ingestion Rate
CF Conversion Factor
EF Exposure Frequency
ED Exposure Duration

BW Body Weight
AT Averaging Time
ADD Average Daily Dose
Lifetime Average Daily Dose
CSFo Cancer Slope Factor (oral)

RfDo Reference Dose (oral)
HQ Hazard Quotient
HI Hazard Index
ND Not Detected
NA Not Applicable

| Total Route–Specific Risk | Cancer | HI |
|---|---|---|
| | NA | 0.3 |

**Table B23**
**Ingestion Exposure Doses and Risks for Resident A Child Exposed to Groundwater**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | RME (ug/L) | IR (L/day) | CF (mg/ug) | EF (d/yr) | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFo (mg/kg/day)−1 | RfDo (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Manganese | 31.2 | 1 | 0.001 | 350 | 6 | 15 | 2190 | 2.0E−03 | 1.7E−04 | NA | 5E−03 | NA | 0.4 |

RME Reasonable Max Exp
IR Ingestion Rate
CF Conversion Factor
EF Exposure Frequency
ED Exposure Duration
BW Body Weight
AT Averaging Time
ADD Average Daily Dose
Lifetime Average Daily Dose
CSFo Cancer Slope Factor (oral)
RfDo Reference Dose (oral)
HQ Hazard Quotient
HI Hazard Index
ND Not Detected
NA Not Applicable

| Total Route−Specific Risk | Cancer | HI |
|---|---|---|
| | NA | 0.4 |

**Table B24**
**Ingestion Exposure Doses and Risks for Resident A 24–yr Adult Exposed to Groundwater**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | RME (ug/L) | IR (L/day) | CF (mg/ug) | EF (d/yr) | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFo (mg/kg/day)–1 | RfDo (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Manganese | 31.2 | 2 | 0.001 | 350 | 24 | 70 | 8760 | 8.5E–04 | 2.9E–04 | NA | 5E–03 | NA | 0.2 |

RME Reasonable Max Exp
IR Ingestion Rate
CF Conversion Factor
EF Exposure Frequency
ED Exposure Duration
BW Body Weight
AT Averaging Time
ADD Average Daily Dose
Lifetime Average Daily Dose
CSFo Cancer Slope Factor (oral)
RfDo Reference Dose (oral)
HQ Hazard Quotient
HI Hazard Index
ND Not Detected
NA Not Applicable

| Total Route–Specific Risk | Cancer | HI |
|---|---|---|
| | NA | 0.2 |

Table B25
Ingestion Exposure Doses and Risks for Resident A 30–yr Adult Exposed to Groundwater
Bell Landfill Site
Towanda, Pennsylvania

| Contaminant of Concern | RME (ug/L) | IR (L/day) | CF (mg/ug) | EF (d/yr) | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFo (mg/kg/day)–1 | RfDo (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Manganese | 31.2 | 2 | 0.001 | 350 | 30 | 70 | 10950 | 8.5E–04 | 3.7E–04 | NA | 5E–03 | NA | 0.2 |

RME Reasonable Max Exp
IR Ingestion Rate
CF Conversion Factor
EF Exposure Frequency
ED Exposure Duration

BW Body Weight
AT Averaging Time
ADD Average Daily Dose
Lifetime Average Daily Dose
CSFo Cancer Slope Factor (oral)

RfDo Reference Dose (oral)
HQ Hazard Quotient
HI Hazard Index
ND Not Detected
NA Not Applicable

| Total Route–Specific Risk | Cancer | HI |
|---|---|---|
| | NA | 0.2 |

**Table B26**
**Equations and Example Calculations for Dermal Exposure to Groundwater**
**Bell Landfill Site**
**Towanda, Pennsylvania**

Equation Definition:

ADD = C x SA x PC x ET x EF x ED x CF / BW x AT

| Parameter | Definition |
|---|---|
| ADD | average daily dose |
| LADD | lifetime average daily dose |
| C | chemical concentration in water (mg/L) |
| SA | skin surface area available for contact (cm2) |
| PC | dermal permeability constant (cm/hr) |
| ET | exposure time (hr/d) |
| EF | exposure frequency (d/yr) |
| ED | exposure duration (yr) |
| CF | volumetric conversion factor for water (1 L/1000 cm3) |
| BW | body weight (kg) |
| AT | averaging time (70 yr for cancer risk; 6 yr for child resident for noncancer risk) |

Example Calculations (child resident "C" exposed to arsenic)

Noncancer Risk

ADD = 0.0012 (mg/L) x 7200 (cm2) x 1.6E−4 (cm/hr) x 2 (hr/d) x 350 (d/yr) x 6 (yr) x 0.001 (L/cm3) /
15 (kg) x 6 (yr) x 365 (days/yr)
ADD = 2.9E−8 (mg/kg/d)

Cancer Risk

LADD = ADD x ED / 70(yr)
LADD = 2.9E−8 (mg/kg/d) x 6 (yr) / 70 (yr)
LADD = 2.5E−9 (mg/kg/d)

Toxicity values were adjusted from an administered to an absorbed dose as follows:

Examples: RfD(oral) for bis(2−ethylhexyl)phthalate x 0.50 (default) = RfD(absorbed)
2E−2 (mg/kg/day) x 0.20 = 1E−2 (mg/kg/day)

CSF(oral) for bis(2−ethylhexyl)phthalate / 0.50 (default) = CSF(absorbed)
1.4E−2 [(mg/kg/day)]−1 / 0.50 = 2.8E−2 [(mg/kg/day)]−1

Source:
Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual (Part A), December 1989.

Table B27
Dermal Exposure Doses and Risks for Resident C Child Exposed to Groundwater
Bell Landfill Site
Towanda, Pennsylvania

| Contaminant of Concern | RME (mg/L) | SA (cm2) | PC (1) (cm/hr) | ET (hr/d) | EF (d/yr) | ED (yrs) | CF (L/cm3) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFd [(mg/kg/day)−1] | RfDd (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 0.0012 | 7200 | 1.6E−04 | 0.33 | 350 | 6 | 0.001 | 15 | 2190 | 2.9E−08 | 2.5E−09 | 8.8E+00 | 6.0E−05 | 2E−08 | 0.0005 |
| Bis(2−Ethylhexyl)phthalate | 0.021 | 7200 | 4.8E−03 | 0.33 | 350 | 6 | 0.001 | 15 | 2190 | 1.5E−05 | 1.3E−06 | 2.8E−02 | 1.0E−02 | 4E−08 | 0.002 |

| Total Route−Specific Risk | Cancer | HI |
|---|---|---|
| | 6E−08 | 0.002 |

RME Reasonable MaximumExposure
SA Skin Surface Area
PC Dermal Permeability Constant
ET Exposure Time
EF Exposure Frequency
ED Exposure Duration

CF Volumetric Conversion Factor
BW Body Weight
AT Averaging Time
ADD Average Daily Dose
LADD Lifetime Average Daily Dose
CSFd Cancer Slope Factor (dermal)

RfDd Reference Dose (dermal)
HQ Hazard Quotient
HI Hazard Index
ND Not Detected
NA Not Applicable

Note: (1) PC for water used as conservative estimate for arsenic. PC for diethyl phthalate used for bis(2−ethylhexyl)phthalate.

**Table B28**
**Dermal Exposure Doses and Risks for Resident D Child Exposed to Groundwater**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | RME (mg/L) | SA (cm2) | PC (1) (cm/hr) | ET (hr/d) | EF (d/yr) | ED (yrs) | CF (L/cm3) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFd [(mg/kg/day)−1] | RfDd (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 0.0026 | 7200 | 1.6E−04 | 0.33 | 350 | 6 | 0.001 | 15 | 2190 | 6.3E−08 | 5.4E−09 | 8.8E+00 | 6.0E−05 | 4.8E−08 | 0.001 |

RME Reasonable MaximumExposure
SA Skin Surface Area
PC Dermal Permeability Constant
ET Exposure Time
EF Exposure Frequency
ED Exposure Duration

CF Volumetric Conversion Factor
BW Body Weight
AT Averaging Time
ADD Average Daily Dose
LADD Lifetime Average Daily Dose
CSFd Cancer Slope Factor (dermal)

RfDd Reference Dose (dermal)
HQ Hazard Quotient
HI Hazard Index
ND Not Detected
NA Not Applicable

| Total Route−Specific Risk | Cancer | HI |
|---|---|---|
| | 4.8E−08 | 0.001 |

Note: (1) *PC for water used as conservative estimate for arsenic.*

**Table B29**
**Dermal Exposure Doses and Risks for Resident F Child Exposed to Groundwater**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | RME (mg/L) | SA (cm2) | PC (1) (cm/hr) | ET (hr/d) | EF (d/yr) | ED (yrs) | CF (L/cm3) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFd [(mg/kg/day)−1] | RfDd (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Manganese | 0.0540 | 7200 | 1.6E−04 | 0.33 | 350 | 6 | 0.001 | 15 | 2190 | 1.3E−06 | 1.1E−07 | NA | 1.0E−03 | NA | 0.001 |

RME Reasonable MaximumExposure
SA Skin Surface Area
PC Dermal Permeability Constant
ET Exposure Time
EF Exposure Frequency
ED Exposure Duration

CF Volumetric Conversion Factor
BW Body Weight
AT Averaging Time
ADD Average Daily Dose
LADD Lifetime Average Daily Dose
CSFd Cancer Slope Factor (dermal)

RfDd Reference Dose (dermal)
HQ Hazard Quotient
HI Hazard Index
ND Not Detected
NA Not Applicable

| Total Route−Specific Risk | Cancer | HI |
|---|---|---|
| | NA | 0.001 |

Note: (1) PC for water used as conservative estimate for manganese.

**Table B30**
**Dermal Exposure Doses and Risks for Resident A Child Exposed to Groundwater**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | RME (mg/L) | SA (cm2) | PC (1) (cm/hr) | ET (hr/d) | EF (d/yr) | ED (yrs) | CF (L/cm3) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFd [(mg/kg/day)−1] | RfDd (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Manganese | 0.0312 | 7200 | 1.6E−04 | 0.33 | 350 | 6 | 0.001 | 15 | 2190 | 7.6E−07 | 6.5E−08 | NA | 1.0E−03 | NA | 0.001 |

| | | |
|---|---|---|
| Total Route−Specific Risk | Cancer | HI |
| | NA | 0.001 |

RME Reasonable MaximumExposure
SA Skin Surface Area
PC Dermal Permeability Constant
ET Exposure Time
EF Exposure Frequency
ED Exposure Duration

CF Volumetric Conversion Factor
BW Body Weight
AT Averaging Time
ADD Average Daily Dose
LADD Lifetime Average Daily Dose
CSFd Cancer Slope Factor (dermal)

RfDd Reference Dose (dermal)
HQ Hazard Quotient
HI Hazard Index
ND Not Detected
NA Not Applicable

Note: (1) PC for water used as conservative estimate for manganese.

**Table B31**
**Equations and Example Calculations for Ingestion Exposure to Surface Water**
**Bell Landfill Site**
**Towanda, Pennsylvania**

Equation Definition:

ADD = C x CR x ET x EF x ED / BW X AT

| Parameter | Definition |
|---|---|
| ADD | average daily dose |
| LADD | lifetime average daily dose |
| C | chemical concentration in water (mg/L) |
| CR | contact rate (L/hr) |
| ET | exposure time (hr/event) |
| EF | exposure frequency (events/yr) |
| ED | exposure duration (yr) |
| BW | body weight (kg) |
| AT | averaging time (70 yr for cancer risk; 10 yr for child trespasser, 30 yr for adult hunter, 6 yr for child resident for noncncer risk) |

Example Calculations (child trespasser exposed to manganese)

Noncancer Risk

ADD = 0.796 (mg/L) x 0.050 (L/hr) x 2 (hr/day) x 26 (d/yr) x 10 (yr) / 37 (kg) x 10 (yr) x 365 (d/yr)
ADD = 1.5E−4 (mg/kg/d)

Cancer Risk

LADD = ADD x ED / 70 (yr)
LADD = 1.5E−4 (mg/kg/d) x 10 (yr) / 70 (yr)
LADD = 2.2E−5 (mg/kg/d)

Source:
Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual (Part A) December 1989.

## Table B32
## Ingestion Exposure Doses and Risks for Child Trespasser Exposed to Surface Water
## Bell Landfill Site
## Towanda, Pennsylvania

| Contaminant of Concern | RME (mg/L) | CR (L/hr) | ET (hr/d) | EF (d/yr) | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFo [(mg/kg/day)−1] | RfDo (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Manganese | 0.796 | 0.05 | 2 | 26 | 10 | 37 | 3650 | 1.5E−04 | 2.2E−05 | NA | 5E−03 | NA | 0.03 |

| | Cancer | HI |
|---|---|---|
| Total Route−Specific Risk | NA | 0.03 |

RME Reasonable Max Exp
CR Contact Rate
ET Exposure Time
EF Exposure Frequency
ED Exposure Duration

BW Body Weight
AT Averaging Time
ADD Average Daily Dose
LADD Lifetime Average Daily Dose
CSFo Cancer Slope Factor (oral)

RfDo Reference Dose (oral)
HQ Hazard Quotient
HI Hazard Index
ND Not Detected
NA Not Applicable

**Table B33**
**Ingestion Exposure Doses and Risks for Adult Hunter Exposed to Surface Water**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | RME (mg/L) | CR (L/hr) | ET (hr/d) | EF (d/yr) | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFo [(mg/kg/day)−1] | RfDo (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Manganese | 0.796 | 0.05 | 2 | 26 | 30 | 70 | 10950 | 8.1E−05 | 3.5E−05 | NA | 5E−03 | NA | 0.02 |

RME Reasonable Max Exp
CR Contact Rate
ET Exposure Time
EF Exposure Frequency
ED Exposure Duration
BW Body Weight
AT Averaging Time
ADD Average Daily Dose
LADD Lifetime Average Daily Dose
CSFo Cancer Slope Factor (oral)
RfDo Reference Dose (oral)
HQ Hazard Quotient
HI Hazard Index
ND Not Detected
NA Not Applicable

| Total Route−Specific Risk | Cancer | HI |
|---|---|---|
| | NA | 0.02 |

**Table B34**
**Equations and Example Calculations for Dermal Exposure to Surface Water**
**Bell Landfill Site**
**Towanda, Pennsylvania**

Equation Definition:

ADD = C x SA x PC x ET x EF x ED x CF / BW x AT

| Parameter | Definition |
|---|---|
| ADD | average daily dose |
| LADD | lifetime average daily dose |
| C | chemical concentration in water (mg/L) |
| SA | skin surface area available for contact (cm2) |
| PC | dermal permeability constant (cm/hr) |
| ET | exposure time (hr/d) |
| EF | exposure frequency (d/yr) |
| ED | exposure duration (yr) |
| CF | volumetric conversion factor for water (1 L/1000 cm3) |
| BW | body weight (kg) |
| AT | averaging time (70 yr for cancer risk; 10 yr for child trespasser, 30 yr adult hunter, 6 yr for child resident for noncancer risk) |

Example Calculations (child trespasser exposed to manganese)

Noncancer Risk

ADD = 0.796 (mg/L) x 3560 (cm2) x 1.6E−4 (cm/hr) x 2 (hr/d) x 26 (d/yr) x 10 (yr) x 0.001 (L/cm3) / 37 (kg) x 10 (yr) x 365 (days/yr)
ADD = 1.7E−6 (mg/kg/d)

Cancer Risk

LADD = ADD x ED / 70(yr)
LADD = 1.7E−6 (mg/kg/d) x 10 (yr) / 70 (yr)
LADD = 2.5E−7 (mg/kg/d)

Toxicity values were adjusted from an administered to an absorbed dose as follows:

Examples: RfD(oral) for beryllium x 0.20 (default) = RfD(absorbed)
5E−3 (mg/kg/day) x 0.20 = 1E−3 (mg/kg/day)

CSF(oral) for beryllium / 0.20 (default) = CSF(absorbed)
4.3E+0 [(mg/kg/day)]−1 / 0.20 = 2.1E+1 [(mg/kg/day)]−1

Source:
Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual (Part A), December 1989.

**Table B35**
**Dermal Exposure Doses and Risks for Child Trespasser Exposed to Surface Water**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | RME (mg/L) | SA (cm2) | PC (1) (cm/hr) | ET (hr/d) | EF (d/yr) | ED (yrs) | CF (L/cm3) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFd [(mg/kg/day) -1] | RfDd (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Manganese | 0.796 | 3560 | 1.6E-04 | 2 | 26 | 10 | 0.001 | 37 | 3650 | 1.7E-06 | 2.5E-07 | NA | 1E-03 | NA | 0.002 |

RME Reasonable Max Exposure
SA Skin Surface Area
PC Dermal Permeability Constant
ET Exposure Time
EF Exposure Frequency
ED Exposure Duration

CF Volumetric Conversion Factor
BW Body Weight
AT Averaging Time
ADD Average Daily Dose
LADD Lifetime Average Daily Dose
CSFd Cancer Slope Factor (dermal)

RfDd Reference Dose (dermal)
HQ Hazard Quotient
HI Hazard Index
ND Not Detected
NA Not Applicable

| Total Route-Specific Risk | Cancer | HI |
|---|---|---|
| | NA | 0.002 |

Note: (1) Permeability Constant for water used as conservative estimate for inorganics

**Table B36**
**Dermal Exposure Doses and Risks for Adult Hunter Exposed to Surface Water**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | RME (mg/L) | SA (cm2) | PC (1) (cm/hr) | ET (hr/d) | EF (d/yr) | ED (yrs) | CF (L/cm3) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFd [(mg/kg/day)−1] | RfDd (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Manganese | 0.798 | 8620 | 1.6E−04 | 2 | 26 | 30 | 0.001 | 70 | 9125 | 2.2E−06 | 8.0E−07 | NA | 1E−03 | NA | 0.002 |

RME Reasonable Max Exposure
SA Skin Surface Area
PC Dermal Permeability Constant
ET Exposure Time
EF Exposure Frequency
ED Exposure Duration

CF Volumetric Conversion Factor
BW Body Weight
AT Averaging Time
ADD Average Daily Dose
LADD Lifetime Average Daily Dose
CSFd Cancer Slope Factor (dermal)

RfDd Reference Dose (dermal)
HQ Hazard Quotient
HI Hazard Index
ND Not Detected
NA Not Applicable

| Total Route−Specific Risk | Cancer | HI |
|---|---|---|
| | NA | 0.002 |

Note: (1) Permeability Constant for water used as conservative estimate for inorganics

**Table B37**
**Ingestion Exposure Doses and Risks for Child Trespasser Exposed to Sediment**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | RME (mg/kg) | IR (mg/d) | CF (kg/mg) | FI | EF (d/yr) | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/d) | LADD (mg/kg/d) | CSFo [(mg/kg/d)]−1 | RfDo (mg/kg/d) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Manganese | 3620 | 100 | 1E−06 | 1 | 26 | 10 | 37 | 3650 | 7.0E−04 | 1.0E−04 | NA | 1.4E−01 | NA | 0.005 |

RME Reasonable Max Exp
IR Ingestion Rate
CF Conversion Factor
FI Fraction Ingested
EF Exposure Frequency
ED Exposure Duration
BW Body Weight
AT Averaging Time
ADD Average Daily Dose
LADD Lifetime Average Daily Dose
CSFo Cancer Slope Factor (oral)
RfDo Reference Dose (oral)
HQ Hazard Quotient
HI Hazard Index
NA Not Applicable

| Total Route−Specific Risk | Cancer | HI |
|---|---|---|
| | NA | 0.005 |

Table B38
Ingestion Exposure Doses and Risks for Adult Hunter Exposed to Sediment
Bell Landfill Site
Towanda, Pennsylvania

| Contaminant of Concern | RME (mg/kg) | IR (mg/d) | CF (kg/mg) | FI | EF (d/yr) | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/d) | LADD (mg/kg/d) | CSFo [(mg/kg/d)]−1 | RfDo (mg/kg/d) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Manganese | 3620 | 50 | 1E−06 | 1 | 26 | 30 | 70 | 10950 | 1.8E−04 | 7.9E−05 | NA | 1.4E−01 | NA | 0.001 |

| | Cancer | HI |
|---|---|---|
| Total Route−Specific Risk | NA | 0.001 |

RME Reasonable Max Exp
IR Ingestion Rate
CF Conversion Factor
FI Fraction Ingested
EF Exposure Frequency
ED Exposure Duration
BW Body Weight
AT Averaging Time
ADD Average Daily Dose
LADD Lifetime Average Daily Dose
CSFo Cancer Slope Factor (oral)
RfDo Reference Dose (oral)
HQ Hazard Quotient
HI Hazard Index
NA Not Applicable

**Table B39**
**Equations and Example Calculations for Dermal Exposure to Sediment**
**Bell Landfill Site**
**Towanda, Pennsylvania**

Equation Definition:

ADD = C x CF x SA x AF x ABS x EF x ED / BW x AT

| Parameter | Definition |
|---|---|
| ADD | average daily dose |
| LADD | lifetime average daily dose |
| C | chemical concentration in soil (mg/kg) |
| CF | conversion factor (kg/mg) |
| SA | skin surface area available for contact (cm2/day) |
| AF | soil to skin adherence factor (mg/cm2) |
| ABS | absorption factor (1.0% for organics, 0.1% for inorganics) |
| EF | exposure frequency (d/yr) |
| ED | exposure duration (yr) |
| BW | body weight (kg) |
| AT | averaging time (70 yr for cancer risk, ED (10 yr child trespasser, 30 yr adult hunter noncancer risk) |

Example Calculations (child trespasser exposed to manganese)

Noncancer Risk

ADD = 3,620 (mg/kg) x 1E−6 (kg/mg) x 7,200 (cm2/day) x 1.0 (mg/cm2) x 0.001 x 26 (d/yr) x 10 (yr) /
37 (kg) x 10 (yr) x 365 (d/yr)
ADD = 5.0E−5 (mg/kg/d)

Cancer Risk

LADD = ADD x ED / 70 (yr)
LADD = 5.0E−5 (mg/kg/d) x 10 (yr) / 70 (yr)
LADD = 7.2E−6 (mg/kg/d)

Toxicity values were adjusted from an administered to an absorbed dose according to the method described in EPA, 1989.

Examples: RfD(oral) for manganese x 0.20 = RfD(absorbed)
5.0E−3 (mg/kg/day) x 0.20 = 1E−3 (mg/kg/day)

Sources:
Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual (Part A), December 1989.
Dermal Exposure Assessment: Principles and Applications, January 1992.

**Table B40**
**Dermal Exposure Doses and Risks for Child Trespasser Exposed to Sediment**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant Of Concern | RME (mg/kg) | CF (kg/mg) | SA (cm2) | AF (mg/cm2) | ABS | EF (d/yr) | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/d) | LADD (mg/kg/d) | CSFd [(mg/kg/d)]−1 | RfDd (mg/kg/d) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Manganese | 3620 | 1E−06 | 3560 | 1 | 0.001 | 26 | 10 | 37 | 3650 | 2.5E−05 | 3.5E−06 | NA | 3.0E−02 | NA | 0.001 |

RME Reasonable Max Exp
CF Conversion Factor
SA Surface Area
AF Adherence Factor
ABS Dermal Absorption Factor
EF Exposure Frequency
ED Exposure Duration
BW Body Weight
AT Averaging Time
ADD Average Daily Dose
LADD Lifetime Average Daily Dose
CSFd Cancer Slope Factor (dermal)
RfDd Reference Dose (dermal)
HQ Hazard Quotient
HI Hazard Index
NA Not Applicable

Total Route−Specific Risk NA 0.001

**Table B41**
**Dermal Exposure Doses and Risks for Adult Hunter Exposed to Sediment**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant Of Concern | RME (mg/kg) | CF (kg/mg) | SA (cm2) | AF (mg/cm2) | ABS | EF (d/yr) | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/d) | LADD (mg/kg/d) | CSFd [(mg/kg/d)]−1 | RfDd (mg/kg/d) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Manganese | 3620 | 1E−06 | 8620 | 1 | 0.001 | 26 | 30 | 70 | 10950 | 3.2E−05 | 1.4E−05 | NA | 3.0E−02 | NA | 0.001 |

RME Reasonable Max Exp
CF Conversion Factor
SA Surface Area
AF Adherence Factor
ABS Dermal Absorption Factor
EF Exposure Frequency
ED Exposure Duration
BW Body Weight
AT Averaging Time
ADD Average Daily Dose
LADD Lifetime Average Daily Dose
CSFd Cancer Slope Factor (dermal)
RfDd Reference Dose (dermal)
HQ Hazard Quotient
HI Hazard Index
NA Not Applicable

Total Route−Specific Risk NA 0.001

# Appendix C

## Risk Calculations for Future Use Scenario

**Table C1**
**Ingestion Exposure Doses and Risks for Child Resident Exposed to Leachate**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | RME (mg/L) | CR (L/hr) | ET (hrs/da | EF (days/ | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFo [(mg/kg/day)−1] | RfDo (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 0.0231 | 0.025 | 2 | 104 | 6 | 15 | 2190 | 2.2E−05 | 1.9E−06 | 1.75E+00 | 3E−04 | 3E−06 | 0.1 |
| Cadmium | 0.166 | 0.025 | 2 | 104 | 6 | 15 | 2190 | 1.6E−04 | 1.4E−05 | NA | 5E−04 | NA | 0.3 |
| Chromium | 0.227 | 0.025 | 2 | 104 | 6 | 15 | 2190 | 2.2E−04 | 1.8E−05 | NA | 5E−03 | NA | 0.04 |
| Cobalt | 1.44 | 0.025 | 2 | 104 | 6 | 15 | 2190 | 1.4E−03 | 1.2E−04 | NA | 6E−02 | NA | 0.02 |
| Manganese | 108 | 0.025 | 2 | 104 | 6 | 15 | 2190 | 1.0E−01 | 8.8E−03 | NA | 5E−03 | NA | 20.5 |
| Molybdenum | 1.8 | 0.025 | 2 | 104 | 6 | 15 | 2190 | 1.7E−03 | 1.5E−04 | NA | 5E−03 | NA | 0.3 |
| 1,2−Dichloroethene (total) | 0.59 | 0.025 | 2 | 104 | 6 | 15 | 2190 | 5.6E−04 | 4.8E−05 | NA | 1E−02 | NA | 0.1 |
| Acetone | 5.4 | 0.025 | 2 | 104 | 6 | 15 | 2190 | 5.1E−03 | 4.4E−04 | NA | 1E−01 | NA | 0.1 |
| Benzene | 0.013 | 0.025 | 2 | 104 | 6 | 15 | 2190 | 1.2E−05 | 1.1E−06 | 2.9E−02 | NA | 3E−08 | NA |
| Methylene Chloride | 28 | 0.025 | 2 | 104 | 6 | 15 | 2190 | 2.7E−02 | 2.3E−03 | 7.5E−03 | 6E−02 | 2E−05 | 0.4 |
| Toluene | 0.92 | 0.025 | 2 | 104 | 6 | 15 | 2190 | 8.7E−04 | 7.5E−05 | NA | 2E−01 | NA | 0.004 |
| Trichloroethene | 0.35 | 0.025 | 2 | 104 | 6 | 15 | 2190 | 3.3E−04 | 2.8E−05 | 1.1E−02 | 6E−03 | 3E−07 | 0.1 |
| Vinyl Chloride | 0.044 | 0.025 | 2 | 104 | 6 | 15 | 2190 | 4.2E−05 | 3.6E−06 | 1.9E+00 | NA | 7E−06 | NA |
| Heptachlor epoxide | 0.000021 | 0.025 | 2 | 104 | 6 | 15 | 2190 | 2.0E−08 | 1.7E−09 | 9.1E+00 | 1.3E−05 | 2E−08 | 0.002 |
| 4−Methylphenol | 3.8 | 0.025 | 2 | 104 | 6 | 15 | 2190 | 3.6E−03 | 3.1E−04 | NA | 5E−02 | NA | 0.1 |
| delta−BHC | 0.0047 | 0.025 | 2 | 104 | 6 | 15 | 2190 | 4.5E−06 | 3.8E−07 | 1.8E+00 | NA | 7E−07 | NA |

RME Reasonable Maximum Exposure
CR Contact Rate
ET Exposure Time
EF Exposure Frequency
ED Exposure Duration

BW Body Weight
AT Averaging Time
ADD Average Daily Dose
LADD Lifetime Average Daily Dose
CSFo Cancer Slope Factor (oral)

RfDo Reference Dose (oral)
HQ Hazard Quotient
HI Hazard Index
ND Not Detected
NA Not Applicable

| Total Route−Specific Risk | Cancer | HI |
|---|---|---|
| | 3E−05 | 22.0 |

**Table C2**
**Dermal Exposure Doses for Child Resident Exposed to Leachate**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | RME (mg/L) | SA (cm2) | PC (1) (cm/hr) | ET (hr/d) | EF (d/yr) | ED (yrs) | CF (L/cm3) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFd [(mg/kg/day)-1] | RfDd (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 0.0231 | 1860 | 1.6E-04 | 2 | 104 | 6 | 0.001 | 15 | 2190 | 2.6E-07 | 2.2E-08 | 8.8E+00 | 6E-05 | 2E-07 | 0.004 |
| Cadmium | 0.166 | 1860 | 1.6E-04 | 2 | 104 | 6 | 0.001 | 15 | 2190 | 1.9E-06 | 1.6E-07 | NA | 1E-04 | NA | 0.02 |
| Chromium | 0.227 | 1860 | 1.6E-04 | 2 | 104 | 6 | 0.001 | 15 | 2190 | 2.6E-06 | 2.2E-07 | NA | 1E-03 | NA | 0.003 |
| Cobalt | 1.44 | 1860 | 1.6E-04 | 2 | 104 | 6 | 0.001 | 15 | 2190 | 1.6E-05 | 1.4E-06 | NA | 1E-02 | NA | 0.002 |
| Manganese | 108 | 1860 | 1.6E-04 | 2 | 104 | 6 | 0.001 | 15 | 2190 | 1.2E-03 | 1.0E-04 | NA | 1E-03 | NA | 1.2 |
| Molybdenum | 1.8 | 1860 | 1.6E-04 | 2 | 104 | 6 | 0.001 | 15 | 2190 | 2.0E-05 | 1.7E-06 | NA | 1E-03 | NA | 0.02 |
| 1,2-Dichloroethene (total) | 0.59 | 1860 | 1.0E-02 | 2 | 104 | 6 | 0.001 | 15 | 2190 | 4.2E-04 | 3.6E-05 | NA | 8E-03 | NA | 0.05 |
| Acetone | 5.4 | 1860 | 1.1E-03 | 2 | 104 | 6 | 0.001 | 15 | 2190 | 4.2E-04 | 3.6E-05 | NA | 8E-02 | NA | 0.005 |
| Benzene | 0.013 | 1860 | 2.1E-02 | 2 | 104 | 6 | 0.001 | 15 | 2190 | 1.9E-05 | 1.7E-06 | 3.6E-02 | NA | 6E-08 | NA |
| Methylene Chloride | 28 | 1860 | 4.5E-03 | 2 | 104 | 6 | 0.001 | 15 | 2190 | 8.9E-03 | 7.6E-04 | 9.4E-03 | 5E-02 | 7E-06 | 0.2 |
| Toluene | 0.92 | 1860 | 4.5E-02 | 2 | 104 | 6 | 0.001 | 15 | 2190 | 2.9E-03 | 2.5E-04 | NA | 2E-01 | NA | 0.01 |
| Trichloroethene | 0.35 | 1860 | 1.6E-02 | 2 | 104 | 6 | 0.001 | 15 | 2190 | 4.0E-04 | 3.4E-05 | 1.4E-02 | 5E-03 | 5E-07 | 0.1 |
| Vinyl Chloride | 0.044 | 1860 | 7.3E-03 | 2 | 104 | 6 | 0.001 | 15 | 2190 | 2.3E-05 | 1.9E-06 | 2.4E+00 | NA | 5E-06 | NA |
| Heptachlor epoxide | 0.000021 | 1860 | 1.1E-02 | 2 | 104 | 6 | 0.001 | 15 | 2190 | 1.6E-08 | 1.4E-09 | 1.8E+01 | 7E-06 | 3E-08 | 0.003 |
| 4-Methylphenol | 3.8 | 1860 | 1.0E-02 | 2 | 104 | 6 | 0.001 | 15 | 2190 | 2.7E-03 | 2.3E-04 | NA | 3E-02 | NA | 0.1 |
| delta-BHC | 0.0047 | 1860 | 1.4E-02 | 2 | 104 | 6 | 0.001 | 15 | 2190 | 4.6E-06 | 4.0E-07 | 3.6E+00 | NA | 1E-06 | NA |

RME Reasonable Maximum Exposure
SA Skin Surface Area
PC Dermal Permeability Constant
ET Exposure Time
EF Exposure Frequency
ED Exposure Duration

CF Volumetric Conversion Factor
BW Body Weight
AT Averaging Time
ADD Average Daily Dose
LADD Lifetime Average Daily Dose
CSFd Cancer Slope Factor (dermal)

RfDd Reference Dose (dermal)
HQ Hazard Quotient
HI Hazard Index
ND Not Detected
NA Not Applicable

| Total Route-Specific Risk | Cancer | HI |
|---|---|---|
| | 1E-05 | 1.7 |

Note: (1) Permeability Constant for water used as conservative estimate for inorganics

**Table C3**
**Ingestion Exposure Doses and Risks for Child Resident Exposed to Soil**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | RME (mg/kg) | IR (mg/d) | CF (kg/mg) | FI | EF (d/yr) | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/d) | LADD (mg/kg/d) | CSFo [(mg/kg/d)]−1 | RfDo (mg/kg/d) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 11.4 | 200 | 1E−06 | 1 | 350 | 6 | 15 | 2190 | 1.5E−04 | 1.2E−05 | 1.75E+00 | 3E−04 | 2E−05 | 0.5 |
| Barium | 354 | 200 | 1E−06 | 1 | 350 | 6 | 15 | 2190 | 4.5E−03 | 3.9E−04 | NA | 7E−02 | NA | 0.1 |
| Beryllium | 0.55 | 200 | 1E−06 | 1 | 350 | 6 | 15 | 2190 | 7.1E−06 | 6.1E−07 | 4.3E+00 | 5E−03 | 3E−06 | 0.001 |
| Cadmium | 134 | 200 | 1E−06 | 1 | 350 | 6 | 15 | 2190 | 1.7E−03 | 1.5E−04 | NA | 5E−04 | NA | 3.4 |
| Chromium | 30 | 200 | 1E−06 | 1 | 350 | 6 | 15 | 2190 | 3.8E−04 | 3.3E−05 | NA | 5E−03 | NA | 0.1 |
| Lead | 3166 | 200 | 1E−06 | 1 | 350 | 6 | 15 | 2190 | 4.0E−02 | 3.5E−03 | NA | NA | NA | NA |
| Manganese | 10100 | 200 | 1E−06 | 1 | 350 | 6 | 15 | 2190 | 1.3E−01 | 1.1E−02 | NA | 1E−01 | NA | 0.9 |
| Mercury | 1 | 200 | 1E−06 | 1 | 350 | 6 | 15 | 2190 | 1.3E−05 | 1.1E−06 | NA | 3E−04 | NA | 0.04 |
| Benzo(a)pyrene | 0.12 | 200 | 1E−06 | 1 | 350 | 6 | 15 | 2190 | 1.5E−06 | 1.3E−07 | 7.3E+00 | NA | 1E−06 | NA |

RME Reasonable Maximum Exposure
IR Ingestion Rate
CF Conversion Factor
FI Fraction Ingested
EF Exposure Frequency
ED Exposure Duration
BW Body Weight
AT Averaging Time
ADD Average Daily Dose
LADD Lifetime Average Daily Dose
CSFo Cancer Slope Factor (oral)
RfDo Reference Dose (oral)
HQ Hazard Quotient
HI Hazard Index
NA Not Applicable

| Total Route−Specific Risk | Cancer | HI |
|---|---|---|
| | 2E−05 | 5.0 |

**Table C4**
**Ingestion Exposure Doses and Risks for Adult Worker Exposed to Soil**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | RME (mg/kg) | IR (mg/d) | CF (kg/mg) | FI | EF (d/yr) | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/d) | LADD (mg/kg/d) | CSFo [(mg/kg/d)]−1 | RfDo (mg/kg/d) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 11.4 | 50 | 1E−06 | 1 | 250 | 25 | 70 | 9125 | 5.6E−06 | 2.0E−06 | 1.75E+00 | 3E−04 | 3E−06 | 0.02 |
| Barium | 354 | 50 | 1E−06 | 1 | 250 | 25 | 70 | 9125 | 1.7E−04 | 6.2E−05 | NA | 7E−02 | NA | 0.002 |
| Beryllium | 0.55 | 50 | 1E−06 | 1 | 250 | 25 | 70 | 9125 | 2.7E−07 | 9.7E−08 | 4.3E+00 | 5E−03 | 4E−07 | 0.0001 |
| Cadmium | 134 | 50 | 1E−06 | 1 | 250 | 25 | 70 | 9125 | 6.6E−05 | 2.3E−05 | NA | 5E−04 | NA | 0.1 |
| Chromium | 30 | 50 | 1E−06 | 1 | 250 | 25 | 70 | 9125 | 1.5E−05 | 5.2E−06 | NA | 5E−03 | NA | 0.003 |
| Lead | 3166 | 50 | 1E−06 | 1 | 250 | 25 | 70 | 9125 | 1.5E−03 | 5.5E−04 | NA | NA | NA | NA |
| Manganese | 10100 | 50 | 1E−06 | 1 | 250 | 25 | 70 | 9125 | 4.9E−03 | 1.8E−03 | NA | 1E−01 | NA | 0.04 |
| Mercury | 1 | 50 | 1E−06 | 1 | 250 | 25 | 70 | 9125 | 4.9E−07 | 1.7E−07 | NA | 3E−04 | NA | 0.002 |
| Benzo(a)pyrene | 0.12 | 50 | 1E−06 | 1 | 250 | 25 | 70 | 9125 | 5.9E−08 | 2.1E−08 | 7.3E+00 | NA | 2E−07 | NA |

RME Reasonable Maximum Exposure
IR Ingestion Rate
CF Conversion Factor
FI Fraction Ingested
EF Exposure Frequency
ED Exposure Duration
BW Body Weight
AT Averaging Time
ADD Average Daily Dose
LADD Lifetime Average Daily Dose
CSFo Cancer Slope Factor (oral)
RfDo Reference Dose (oral)
HQ Hazard Quotient
HI Hazard Index
NA Not Applicable

| Total Route−Specific Risk | Cancer | HI |
|---|---|---|
| | 4E−06 | 0.2 |

**Table C5**
**Inhalation Exposure Doses and Risks for Child Resident Exposed to Soil**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | RME (mg/kg) | ED (yrs) | EF (d/yr) | IR (m3/d) | PEF (m3/kg) | BW (kg) | AT (days) | ADD (mg/kg/d) | LADD (mg/kg/d) | CSFi [(mg/kg/d)]−1 | RfDi (mg/kg/d) | Cancer | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 11.4 | 6 | 350 | 20 | 4.63E+09 | 15 | 2190 | 3.1E−09 | 2.7E−10 | 1.5E+01 | NA | 4E−09 | NA |
| Barium | 354 | 6 | 350 | 20 | 4.63E+09 | 15 | 2190 | 9.8E−08 | 8.4E−09 | NA | NA | NA | NA |
| Beryllium | 0.55 | 6 | 350 | 20 | 4.63E+09 | 15 | 2190 | 1.5E−10 | 1.3E−11 | 8.4E+00 | NA | 1E−10 | NA |
| Cadmium | 134 | 6 | 350 | 20 | 4.63E+09 | 15 | 2190 | 3.7E−08 | 3.2E−09 | 6.3E+00 | NA | 2E−08 | NA |
| Chromium | 30 | 6 | 350 | 20 | 4.63E+09 | 15 | 2190 | 8.3E−09 | 7.1E−10 | 4.2E+01 | NA | 3E−08 | NA |
| Lead | 3166 | 6 | 350 | 20 | 4.63E+09 | 15 | 2190 | 8.7E−07 | 7.5E−08 | NA | NA | NA | NA |
| Manganese | 10100 | 6 | 350 | 20 | 4.63E+09 | 15 | 2190 | 2.8E−06 | 2.4E−07 | NA | NA | NA | NA |
| Mercury | 1 | 6 | 350 | 20 | 4.63E+09 | 15 | 2190 | 2.8E−10 | 2.4E−11 | NA | 8.6E−05 | NA | 0.000003 |
| Benzo(a)pyrene | 0.12 | 6 | 350 | 20 | 4.63E+09 | 15 | 2190 | 3.3E−11 | 2.8E−12 | NA | NA | NA | NA |

RME Reasonable Max Exposure
ED Exposure Duration
EF Exposure Frequency
IR Inhalation Rate
PEF Particulate Emissions Factor
BW Body Weight
Averaging Time
ADD Average Daily Dose
LADD Lifetime Average Daily Dose
CSFi Cancer Slope Factor (inhalation)
RfDi Reference Dose (inhalation)
HQ Hazard Quotient
HI Hazard Index
NA Not Applicable

| Total Route−Specific Risk | Cancer | HI |
|---|---|---|
| | 5E−08 | 0.000003 |

**Table C6**
**Inhalation Exposure Doses and Risks for Adult Worker Exposed to Soil**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | RME (mg/kg) | ED (yrs) | EF (d/yr) | IR (m3/d) | PEF (m3/kg) | BW (kg) | AT (days) | ADD (mg/kg/d) | LADD (mg/kg/d) | CSFi [(mg/kg/d)]−1 | RfDI (mg/kg/d) | Cancer | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 11.4 | 25 | 250 | 20 | 4.63E+09 | 70 | 9125 | 4.8E−10 | 1.7E−10 | 1.5E+01 | NA | 3E−09 | NA |
| Barium | 354 | 25 | 250 | 20 | 4.63E+09 | 70 | 9125 | 1.5E−08 | 5.3E−09 | NA | NA | NA | NA |
| Beryllium | 0.55 | 25 | 250 | 20 | 4.63E+09 | 70 | 9125 | 2.3E−11 | 8.4E−12 | 8.4E+00 | NA | 7E−11 | NA |
| Cadmium | 134 | 25 | 250 | 20 | 4.63E+09 | 70 | 9125 | 5.7E−09 | 2.0E−09 | 6.3E+00 | NA | 1E−08 | NA |
| Chromium | 30 | 25 | 250 | 20 | 4.63E+09 | 70 | 9125 | 1.3E−09 | 4.5E−10 | 4.2E+01 | NA | 2E−08 | NA |
| Lead | 3166 | 25 | 250 | 20 | 4.63E+09 | 70 | 9125 | 1.3E−07 | 4.8E−08 | NA | NA | NA | NA |
| Manganese | 10100 | 25 | 250 | 20 | 4.63E+09 | 70 | 9125 | 4.3E−07 | 1.5E−07 | NA | NA | NA | NA |
| Mercury | 1 | 25 | 250 | 20 | 4.63E+09 | 70 | 9125 | 4.2E−11 | 1.5E−11 | NA | 8.6E−05 | NA | 0.0000005 |
| Benzo(a)pyrene | 0.12 | 25 | 250 | 20 | 4.63E+09 | 70 | 9125 | 5.1E−12 | 1.8E−12 | NA | NA | NA | NA |

RME Reasonable Max Exposure
ED Exposure Duration
EF Exposure Frequency
IR Inhalation Rate
PEF Particulate Emissions Factor
BW Body Weight
Averaging Time
ADD Average Daily Dose
LADD Lifetime Average Daily Dose
CSFi Cancer Slope Factor (inhalation)
RfDI Reference Dose (inhalation)
HQ Hazard Quotient
HI Hazard Index
NA Not Applicable

| Total Route−Specific Risk | Cancer | HI |
|---|---|---|
| | 3E−08 | 0.0000005 |

Table C7
Ingestion Exposure Doses and Risks for Child Resident Exposed to Groundwater
Bell Landfill Site
Towanda, Pennsylvania

| Contaminant of Concern | RME (ug/L) | IR (L/d) | CF (mg/ug) | EF (d/yr) | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFo (mg/kg/day)−1 | RfDo (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aluminum | 32800 | 1 | 0.001 | 350 | 6 | 15 | 2190 | 2.1E+00 | 1.8E−01 | NA | 2.9E+00 | NA | 0.7 |
| Arsenic | 31.3 | 1 | 0.001 | 350 | 6 | 15 | 2190 | 2.0E−03 | 1.7E−04 | 1.75E+00 | 3E−04 | 3E−04 | 6.7 |
| Barium | 908 | 1 | 0.001 | 350 | 6 | 15 | 2190 | 5.8E−02 | 5.0E−03 | NA | 7E−02 | NA | 0.8 |
| Beryllium | 2.2 | 1 | 0.001 | 350 | 6 | 15 | 2190 | 1.4E−04 | 1.2E−05 | 4.3E+00 | 5E−03 | 5E−05 | 0.03 |
| Chromium | 161 | 1 | 0.001 | 350 | 6 | 15 | 2190 | 1.0E−02 | 8.8E−04 | NA | 5E−03 | NA | 2.1 |
| Copper | 241 | 1 | 0.001 | 350 | 6 | 15 | 2190 | 1.5E−02 | 1.3E−03 | NA | 3.7E−02 | NA | 0.4 |
| Lead | 50.6 | 1 | 0.001 | 350 | 6 | 15 | 2190 | 3.2E−03 | 2.8E−04 | NA | NA | NA | NA |
| Manganese | 1950 | 1 | 0.001 | 350 | 6 | 15 | 2190 | 1.2E−01 | 1.1E−02 | NA | 5E−03 | NA | 24.9 |
| Nickel | 140 | 1 | 0.001 | 350 | 6 | 15 | 2190 | 8.9E−03 | 7.7E−04 | NA | 2E−02 | NA | 0.4 |
| Vanadium | 45.8 | 1 | 0.001 | 350 | 6 | 15 | 2190 | 2.9E−03 | 2.5E−04 | NA | 7E−03 | NA | 0.4 |
| 1,2−Dichloroethene (total) | 13 | 1 | 0.001 | 350 | 6 | 15 | 2190 | 8.3E−04 | 7.1E−05 | NA | 1E−02 | NA | 0.08 |
| Benzene | 1 | 1 | 0.001 | 350 | 6 | 15 | 2190 | 6.4E−05 | 5.5E−06 | 2.9E−02 | NA | 2E−07 | NA |
| Tetrachloroethene | 5.8 | 1 | 0.001 | 350 | 6 | 15 | 2190 | 3.7E−04 | 3.2E−05 | 5.2E−02 | 1E−02 | 2E−06 | 0.04 |
| Trichloroethene | 25 | 1 | 0.001 | 350 | 6 | 15 | 2190 | 1.6E−03 | 1.4E−04 | 1.1E−02 | 6E−03 | 2E−06 | 0.3 |
| Vinyl Chloride | 5 | 1 | 0.001 | 350 | 6 | 15 | 2190 | 3.2E−04 | 2.7E−05 | 1.9E+00 | NA | 5E−05 | NA |

RME Reasonable Max Exp
IR Ingestion Rate
CF Conversion Factor
EF Exposure Frequency
ED Exposure Duration

BW Body Weight
AT Averaging Time
ADD Average Daily Dose
Lifetime Average Daily Dose
CSFo Cancer Slope Factor (oral)

RfDo Reference Dose (oral)
HQ Hazard Quotient
HI Hazard Index
ND Not Detected
NA Not Applicable

| Total Route−Specific Risk | Cancer | HI |
|---|---|---|
| | 4E−04 | 36.9 |

**Table C8**
**Ingestion Exposure Doses and Risks for 24–yr Adult Resident Exposed to Groundwater**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | RME (ug/L) | IR (L/d) | CF (mg/ug) | EF (d/yr) | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFo (mg/kg/day)–1 | RfDo (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aluminum | 32800 | 2 | 0.001 | 350 | 24 | 70 | 8760 | 9.0E–01 | 3.1E–01 | NA | 2.9E+00 | NA | 0.3 |
| Arsenic | 31.3 | 2 | 0.001 | 350 | 24 | 70 | 8760 | 8.6E–04 | 2.9E–04 | 1.75E+00 | 3E–04 | 5E–04 | 2.9 |
| Barium | 908 | 2 | 0.001 | 350 | 24 | 70 | 8760 | 2.5E–02 | 8.5E–03 | NA | 7E–02 | NA | 0.4 |
| Beryllium | 2.2 | 2 | 0.001 | 350 | 24 | 70 | 8760 | 6.0E–05 | 2.1E–05 | 4.3E+00 | 5E–03 | 9E–05 | 0.01 |
| Chromium | 161 | 2 | 0.001 | 350 | 24 | 70 | 8760 | 4.4E–03 | 1.5E–03 | NA | 5E–03 | NA | 0.9 |
| Copper | 241 | 2 | 0.001 | 350 | 24 | 70 | 8760 | 6.6E–03 | 2.3E–03 | NA | 3.7E–02 | NA | 0.2 |
| Lead | 50.6 | 2 | 0.001 | 350 | 24 | 70 | 8760 | 1.4E–03 | 4.8E–04 | NA | NA | NA | NA |
| Manganese | 1950 | 2 | 0.001 | 350 | 24 | 70 | 8760 | 5.3E–02 | 1.8E–02 | NA | 5E–03 | NA | 10.7 |
| Nickel | 140 | 2 | 0.001 | 350 | 24 | 70 | 8760 | 3.8E–03 | 1.3E–03 | NA | 2E–02 | NA | 0.2 |
| Vanadium | 45.8 | 2 | 0.001 | 350 | 24 | 70 | 8760 | 1.3E–03 | 4.3E–04 | NA | 7E–03 | NA | 0.2 |
| 1,2–Dichloroethene (total) | 13 | 2 | 0.001 | 350 | 24 | 70 | 8760 | 3.6E–04 | 1.2E–04 | NA | 1E–02 | NA | 0.04 |
| Benzene | 1 | 2 | 0.001 | 350 | 24 | 70 | 8760 | 2.7E–05 | 9.4E–06 | 2.9E–02 | NA | 3E–07 | NA |
| Tetrachloroethene | 5.8 | 2 | 0.001 | 350 | 24 | 70 | 8760 | 1.6E–04 | 5.4E–05 | 5.2E–02 | 1E–02 | 3E–06 | 0.02 |
| Trichloroethene | 25 | 2 | 0.001 | 350 | 24 | 70 | 8760 | 6.8E–04 | 2.3E–04 | 1.1E–02 | 6E–03 | 3E–06 | 0.1 |
| Vinyl Chloride | 5 | 2 | 0.001 | 350 | 24 | 70 | 8760 | 1.4E–04 | 4.7E–05 | 1.9E+00 | NA | 9E–05 | NA |

RME Reasonable Max Exp
IR Ingestion Rate
CF Conversion Factor
EF Exposure Frequency
ED Exposure Duration
BW Body Weight
AT Averaging Time
ADD Average Daily Dose
LADD Lifetime Average Daily Dose
CSFo Cancer Slope Factor (oral)
RfDo Reference Dose (oral)
HQ Hazard Quotient
HI Hazard Index
ND Not Detected
NA Not Applicable

| Total Route–Specific Risk | Cancer | HI |
|---|---|---|
| | 7E–04 | 15.8 |

**Table C9**
**Ingestion Exposure Doses and Risks for 30–yr Adult Resident Exposed to Groundwater**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | RME (ug/L) | IR (L/d) | CF (mg/ug) | EF (d/yr) | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFo (mg/kg/day)–1 | RfDo (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aluminum | 32800 | 2 | 0.001 | 350 | 30 | 70 | 10950 | 9.0E–01 | 3.9E–01 | NA | 2.9E+00 | NA | 0.3 |
| Arsenic | 31.3 | 2 | 0.001 | 350 | 30 | 70 | 10950 | 8.6E–04 | 3.7E–04 | 1.75E+00 | 3E–04 | 6E–04 | 2.9 |
| Barium | 908 | 2 | 0.001 | 350 | 30 | 70 | 10950 | 2.5E–02 | 1.1E–02 | NA | 7E–02 | NA | 0.4 |
| Beryllium | 2.2 | 2 | 0.001 | 350 | 30 | 70 | 10950 | 6.0E–05 | 2.6E–05 | 4.3E+00 | 5E–03 | 1E–04 | 0.01 |
| Chromium | 161 | 2 | 0.001 | 350 | 30 | 70 | 10950 | 4.4E–03 | 1.9E–03 | NA | 5E–03 | NA | 0.9 |
| Copper | 241 | 2 | 0.001 | 350 | 30 | 70 | 10950 | 6.6E–03 | 2.8E–03 | NA | 3.7E–02 | NA | 0.2 |
| Lead | 50.6 | 2 | 0.001 | 350 | 30 | 70 | 10950 | 1.4E–03 | 5.9E–04 | NA | NA | NA | NA |
| Manganese | 1950 | 2 | 0.001 | 350 | 30 | 70 | 10950 | 5.3E–02 | 2.3E–02 | NA | 5E–03 | NA | 10.7 |
| Nickel | 140 | 2 | 0.001 | 350 | 30 | 70 | 10950 | 3.8E–03 | 1.6E–03 | NA | 2E–02 | NA | 0.2 |
| Vanadium | 45.8 | 2 | 0.001 | 350 | 30 | 70 | 10950 | 1.3E–03 | 5.4E–04 | NA | 7E–03 | NA | 0.2 |
| 1,2–Dichloroethene (total) | 13 | 2 | 0.001 | 350 | 30 | 70 | 10950 | 3.6E–04 | 1.5E–04 | NA | 1E–02 | NA | 0.04 |
| Benzene | 1 | 2 | 0.001 | 350 | 30 | 70 | 10950 | 2.7E–05 | 1.2E–05 | 2.9E–02 | NA | 3E–07 | NA |
| Tetrachloroethene | 5.8 | 2 | 0.001 | 350 | 30 | 70 | 10950 | 1.6E–04 | 6.8E–05 | 5.2E–02 | 1E–02 | 4E–06 | 0.02 |
| Trichloroethene | 25 | 2 | 0.001 | 350 | 30 | 70 | 10950 | 6.8E–04 | 2.9E–04 | 1.1E–02 | 6E–03 | 3E–06 | 0.1 |
| Vinyl Chloride | 5 | 2 | 0.001 | 350 | 30 | 70 | 10950 | 1.4E–04 | 5.9E–05 | 1.9E+00 | NA | 1E–04 | NA |

RME Reasonable Max Exp
IR Ingestion Rate
CF Conversion Factor
EF Exposure Frequency
ED Exposure Duration

BW Body Weight
AT Averaging Time
ADD Average Daily Dose
Lifetime Average Daily Dose
CSFo Cancer Slope Factor (oral)

RfDo Reference Dose (oral)
HQ Hazard Quotient
HI Hazard Index
ND Not Detected
NA Not Applicable

| Total Route–Specific Risk | Cancer | HI |
|---|---|---|
| | 9E–04 | 15.8 |

**Table C10**
**Ingestion Exposure Doses and Risks for Adult Worker Exposed to Groundwater**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | RME (ug/L) | IR (L/d) | CF (mg/ug) | EF (d/yr) | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFo (mg/kg/day)−1 | RfDo (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aluminum | 32800 | 1 | 0.001 | 250 | 25 | 70 | 9125 | 3.2E−01 | 1.1E−01 | NA | 2.9E+00 | NA | 0.1 |
| Arsenic | 31.3 | 1 | 0.001 | 250 | 25 | 70 | 9125 | 3.1E−04 | 1.1E−04 | 1.75E+00 | 3E−04 | 2E−04 | 1.0 |
| Barium | 908 | 1 | 0.001 | 250 | 25 | 70 | 9125 | 8.9E−03 | 3.2E−03 | NA | 7E−02 | NA | 0.1 |
| Beryllium | 2.2 | 1 | 0.001 | 250 | 25 | 70 | 9125 | 2.2E−05 | 7.7E−06 | 4.3E+00 | 5E−03 | 3E−05 | 0.004 |
| Chromium | 161 | 1 | 0.001 | 250 | 25 | 70 | 9125 | 1.6E−03 | 5.6E−04 | NA | 5E−03 | NA | 0.3 |
| Copper | 241 | 1 | 0.001 | 250 | 25 | 70 | 9125 | 2.4E−03 | 8.4E−04 | NA | 3.7E−02 | NA | 0.1 |
| Lead | 50.6 | 1 | 0.001 | 250 | 25 | 70 | 9125 | 5.0E−04 | 1.8E−04 | NA | NA | NA | NA |
| Manganese | 1950 | 1 | 0.001 | 250 | 25 | 70 | 9125 | 1.9E−02 | 6.8E−03 | NA | 5E−03 | NA | 3.8 |
| Nickel | 140 | 1 | 0.001 | 250 | 25 | 70 | 9125 | 1.4E−03 | 4.9E−04 | NA | 2E−02 | NA | 0.1 |
| Vanadium | 45.8 | 1 | 0.001 | 250 | 25 | 70 | 9125 | 4.5E−04 | 1.6E−04 | NA | 7E−03 | NA | 0.1 |
| 1,2−Dichloroethene (total) | 13 | 1 | 0.001 | 250 | 25 | 70 | 9125 | 1.3E−04 | 4.5E−05 | NA | 1E−02 | NA | 0.01 |
| Benzene | 1 | 1 | 0.001 | 250 | 25 | 70 | 9125 | 9.8E−06 | 3.5E−06 | 2.9E−02 | NA | 1E−07 | NA |
| Tetrachloroethene | 5.8 | 1 | 0.001 | 250 | 25 | 70 | 9125 | 5.7E−05 | 2.0E−05 | 5.2E−02 | 1E−02 | 1E−06 | 0.01 |
| Trichloroethene | 25 | 1 | 0.001 | 250 | 25 | 70 | 9125 | 2.4E−04 | 8.7E−05 | 1.1E−02 | 6E−03 | 1E−06 | 0.04 |
| Vinyl Chloride | 5 | 1 | 0.001 | 250 | 25 | 70 | 9125 | 4.9E−05 | 1.7E−05 | 1.9E+00 | NA | 3E−05 | NA |

| | | | | Cancer | HI |
|---|---|---|---|---|---|
| RME Reasonable Max Exp | BW Body Weight | RfDo Reference Dose (oral) | Total Route−Specific Risk | 3E−04 | 5.6 |
| IR Ingestion Rate | AT Averaging Time | HQ Hazard Quotient | | | |
| CF Conversion Factor | ADD Average Daily Dose | HI Hazard Index | | | |
| EF Exposure Frequency | Lifetime Average Daily Dose | ND Not Detected | | | |
| ED Exposure Duration | CSFo Cancer Slope Factor (oral) | NA Not Applicable | | | |

**Table C11**
**Dermal Exposure Doses and Risks for Child Resident Exposed to Groundwater**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | RME (mg/L) | SA (cm2) | PC (1) (cm/hr) | ET (hr/d) | EF (d/yr) | ED (yrs) | CF (L/cm3) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFd [(mg/kg/day)-1] | RfDd (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aluminum | 32.8 | 7200 | 1.6E-04 | 0.33 | 350 | 6 | 0.001 | 15 | 2190 | 8.0E-04 | 6.8E-05 | NA | 6E-01 | NA | 0.001 |
| Arsenic | 0.0313 | 7200 | 1.6E-04 | 0.33 | 350 | 6 | 0.001 | 15 | 2190 | 7.6E-07 | 6.5E-08 | 8.8E+00 | 6E-05 | 6E-07 | 0.01 |
| Barium | 0.908 | 7200 | 1.6E-04 | 0.33 | 350 | 6 | 0.001 | 15 | 2190 | 2.2E-05 | 1.9E-06 | NA | 1E-02 | NA | 0.002 |
| Beryllium | 0.0022 | 7200 | 1.6E-04 | 0.33 | 350 | 6 | 0.001 | 15 | 2190 | 5.3E-08 | 4.6E-09 | 2.2E+01 | 1E-03 | 1E-07 | 0.0001 |
| Chromium | 0.161 | 7200 | 1.6E-04 | 0.33 | 350 | 6 | 0.001 | 15 | 2190 | 3.9E-06 | 3.4E-07 | NA | 1E-03 | NA | 0.004 |
| Copper | 0.241 | 7200 | 1.6E-04 | 0.33 | 350 | 6 | 0.001 | 15 | 2190 | 5.9E-06 | 5.0E-07 | NA | 7E-03 | NA | 0.001 |
| Lead | 0.0506 | 7200 | 1.6E-04 | 0.33 | 350 | 6 | 0.001 | 15 | 2190 | 1.2E-06 | 1.1E-07 | NA | NA | NA | NA |
| Manganese | 1.95 | 7200 | 1.6E-04 | 0.33 | 350 | 6 | 0.001 | 15 | 2190 | 4.7E-05 | 4.1E-06 | NA | 1E-03 | NA | 0.0 |
| Nickel | 0.14 | 7200 | 1.6E-04 | 0.33 | 350 | 6 | 0.001 | 15 | 2190 | 3.4E-06 | 2.9E-07 | NA | 4E-03 | NA | 0.001 |
| Vanadium | 0.0458 | 7200 | 1.6E-04 | 0.33 | 350 | 6 | 0.001 | 15 | 2190 | 1.1E-06 | 9.5E-08 | NA | 1E-03 | NA | 0.001 |
| 1,2-Dichloroethene (total) | 0.013 | 7200 | 1.0E-02 | 0.33 | 350 | 6 | 0.001 | 15 | 2190 | 2.0E-05 | 1.7E-06 | NA | 1E-02 | NA | 0.002 |
| Benzene | 0.001 | 7200 | 2.1E-02 | 0.33 | 350 | 6 | 0.001 | 15 | 2190 | 3.2E-06 | 2.7E-07 | 3.6E-02 | NA | 1E-08 | NA |
| Tetrachloroethene | 0.0058 | 7200 | 4.8E-02 | 0.33 | 350 | 6 | 0.001 | 15 | 2190 | 4.2E-05 | 3.6E-06 | 6.5E-02 | 8E-03 | 2E-07 | 0.01 |
| Trichloroethene | 0.025 | 7200 | 1.6E-02 | 0.33 | 350 | 6 | 0.001 | 15 | 2190 | 6.1E-05 | 5.2E-06 | 1.4E-02 | 5E-03 | 7E-08 | 0.01 |
| Vinyl Chloride | 0.005 | 7200 | 7.3E-03 | 0.33 | 350 | 6 | 0.001 | 15 | 2190 | 5.5E-06 | 4.8E-07 | 2.4E+00 | NA | 1E-06 | NA |

| | | | | Cancer | HI |
|---|---|---|---|---|---|
| RME Reasonable Max Exposure | CF Volumetric Conversion Factor | RfDd Reference Dose (dermal) | Total Route-Specific Risk | 2E-06 | 0.1 |
| SA Skin Surface Area | BW Body Weight | HQ Hazard Quotient | | | |
| PC Dermal Permeability Constant | AT Averaging Time | HI Hazard Index | | | |
| ET Exposure Time | ADD Average Daily Dose | ND Not Detected | | | |
| EF Exposure Frequency | LADD Lifetime Average Daily Dose | NA Not Applicable | | | |
| ED Exposure Duration | CSFd Cancer Slope Factor (dermal) | | | | |

Note: (1) Permeability Constant for water used as conservative estimate for inorganics

Table C12
24-yr Adult resident showering exposure concentrations.
Bell Landfill Site
Towanda, Pennsylvania

| | | |
|---|---|---|
| L-phase t.c. CO2 | cm/h | 20 |
| G-phase t.c. H2O | cm/h | 3000 |
| Water visc. at 20C | cp | 1.002 |
| Water visc. at 45C | cp | 0.596 |
| Shower temp | K | 318 |
| Droplet diameter | mm | 1 |
| Drop time | s | 2 |
| Shower flow rate | L/min | 20 |
| Shower stall volume | m3 | 2.9 |
| Shower duration | min | 12 |
| Air exchange rate | min-1 | 0.0166667 (RANGE: .5 TO 1.5 PER HOUR) |

| Contaminant | RME Conc. mg/L | Mol. Wt. g/mol | Henry's Constant atm-m3/mol | Kl cm/h | Kg cm/h | Overall Trans. Coeff. KL cm/h | Temp-adj. Trans. Coeff. KaL cm/h | Conc. leaving H2O Cwd mg/l | VOC Gener. Rate S mg/m3-min | Air Conc. at Shower End mg/m3 | Avg. Air Conc. in Shower mg/m3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Benzene | 1.00E-03 | 7.81E+01 | 5.50E-03 | 2E+01 | 1440.2 | 1.44E+01 | 1.92E+01 | 4.73E-04 | 3.26E-03 | 3.55E-02 | 1.83E-02 |
| cis-1,2-Dichloroethene | 1.30E-02 | 9.70E+01 | 4.08E-03 | 1E+01 | 1292.32 | 1.27E+01 | 1.70E+01 | 5.62E-03 | 3.88E-02 | 4.22E-01 | 2.16E-01 |
| Tetrachloroethene | 5.80E-03 | 1.66E+02 | 1.80E-02 | 1E+01 | 9.88E+02 | 1.02E+01 | 1.36E+01 | 2.12E-03 | 1.46E-02 | 1.59E-01 | 8.20E-02 |
| Trichloroethene | 2.50E-02 | 1.31E+02 | 2.00E-02 | 1E+01 | 1.11E+03 | 1.14E+01 | 1.53E+01 | 9.99E-03 | 6.89E-02 | 7.50E-01 | 3.87E-01 |
| Vinyl Chloride | 5.00E-03 | 6.25E+01 | 1.20E+00 | 2E+01 | 1.61E+03 | 1.68E+01 | 2.25E+01 | 2.64E-03 | 1.82E-02 | 1.98E-01 | 1.02E-01 |

Table C12
[redacted]–yr Adult resident showering inhalation.
Bell Landfill Site
Towanda, Pennsylvania

| | | |
|---|---|---|
| Inhalation rate | m3/min | 0.0138889 |
| Exposure frequency | d/y | 350 |
| Exposure duration | y | 24 |
| Body weight | kg | 70 |
| Averaging time carc. | d | 25550 |
| Averaging time ncarc. | d | 8760 |
| Shower duration | min/d | 12 |

| Contaminant | RME Conc. mg/m3 | Lifetime Average Daily Dose mg/kg/d | Chronic Daily Dose mg/kg/d | Lifetime Cancer Risk | Systemic Hazard Quotient |
|---|---|---|---|---|---|
| [redacted]enzene | 1.83E–02 | 1.44E–05 | 4.19E–05 | 4E–07 | 0.3 |
| cis–1,2–Dichloroethene | 2.18E–01 | 1.71E–04 | 4.98E–04 | –– | –– |
| Tetrachloroethene | 8.20E–02 | 6.42E–05 | 1.87E–04 | 1E–07 | –– |
| Trichloroethene | 3.87E–01 | 3.03E–04 | 8.84E–04 | 2E–06 | –– |
| Vinyl Chloride | 1.02E–01 | 8.00E–05 | 2.33E–04 | 2E–05 | –– |
| | Total Route–Specific Risk | | | 3E–05 | 0.3 |

Table C13
30-yr Adult resident showering exposure concentrations.
Bell Landfill Site
Towanda, Pennsylvania

| | | |
|---|---|---|
| L-phase t.c. CO2 | cm/h | 20 |
| G-phase t.c. H2O | cm/h | 3000 |
| Water visc. at 20C | cp | 1.002 |
| Water visc. at 45C | cp | 0.596 |
| Shower temp | K | 318 |
| Droplet diameter | mm | 1 |
| Drop time | s | 2 |
| Shower flow rate | L/min | 20 |
| Shower stall volume | m3 | 2.9 |
| Shower duration | min | 12 |
| Air exchange rate | min-1 | 0.0166667 (RANGE: .5 TO 1.5 PER HOUR) |

| Contaminant | RME Conc. mg/L | Mol. Wt. g/mol | Henry's Constant atm-m3/mol | Kl cm/h | Kg cm/h | Overall Trans. Coeff. KL cm/h | Temp-adj. Trans. Coeff. KaL cm/h | Conc. leaving H2O Cwd mg/l | VOC Gener. Rate S mg/m3-min | Air Conc. at Shower End mg/m3 | Avg. Air Conc. in Shower mg/m3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Benzene | 1.00E-03 | 7.81E+01 | 5.50E-03 | 2E+01 | 1440 | 1.44E+01 | 1.92E+01 | 4.73E-04 | 3.26E-03 | 3.55E-02 | 1.83E-02 |
| cis-1,2-Dichloroethene | 1.30E-02 | 9.70E+01 | 4.08E-03 | 1E+01 | 1292.32 | 1.27E+01 | 1.70E+01 | 5.62E-03 | 3.88E-02 | 4.22E-01 | 2.18E-01 |
| Tetrachloroethene | 5.80E-03 | 1.66E+02 | 1.80E-02 | 1E+01 | 9.88E+02 | 1.02E+01 | 1.36E+01 | 2.12E-03 | 1.46E-02 | 1.59E-01 | 8.20E-02 |
| Trichloroethene | 2.50E-02 | 1.31E+02 | 2.00E-02 | 1E+01 | 1.11E+03 | 1.14E+01 | 1.53E+01 | 9.99E-03 | 6.89E-02 | 7.50E-01 | 3.87E-01 |
| Vinyl Chloride | 5.00E-03 | 6.25E+01 | 1.20E+00 | 2E+01 | 1.61E+03 | 1.68E+01 | 2.25E+01 | 2.64E-03 | 1.82E-02 | 1.98E-01 | 1.02E-01 |

Table C13
30-yr Adult resident showering inhalation.
Bell Landfill Site
Towanda, Pennsylvania

| | | |
|---|---|---|
| Inhalation rate | m3/min | 0.0138889 |
| Exposure frequency | d/y | 350 |
| Exposure duration | y | 30 |
| Body weight | kg | 70 |
| Averaging time carc. | d | 25550 |
| Averaging time ncarc. | d | 10950 |
| Shower duration | min/d | 12 |

| Contaminant | RME Conc. mg/m3 | Lifetime Average Daily Dose mg/kg/d | Chronic Daily Dose mg/kg/d | Lifetime Cancer Risk | Systemic Hazard Quotient |
|---|---|---|---|---|---|
| Benzene | 1.83E-02 | 1.79E-05 | 4.19E-05 | 5E-07 | 0.3 |
| cis-1,2-Dichloroethene | 2.18E-01 | 2.13E-04 | 4.98E-04 | -- | -- |
| Tetrachloroethene | 8.20E-02 | 8.02E-05 | 1.87E-04 | 2E-07 | -- |
| Trichloroethene | 3.87E-01 | 3.79E-04 | 8.84E-04 | 2E-06 | -- |
| Vinyl Chloride | 1.02E-01 | 1.00E-04 | 2.33E-04 | 3E-05 | -- |
| | Total Route-Specific Risk | | | 3E-05 | 0.3 |

Table C14
Adult worker showering exposure concentrations.
Bell Landfill Site
Towanda, Pennsylvania

| | | |
|---|---|---|
| L-phase t.c. CO2 | cm/h | 20 |
| G-phase t.c. H2O | cm/h | 3000 |
| Water visc. at 20C | cp | 1.002 |
| Water visc. at 45C | cp | 0.596 |
| Shower temp | K | 318 |
| Droplet diameter | mm | 1 |
| Drop time | s | 2 |
| Shower flow rate | L/min | 20 |
| Shower stall volume | m3 | 2.9 |
| Shower duration | min | 12 |
| Air exchange rate | min-1 | 0.0166667 (RANGE: .5 TO 1.5 PER HOUR) |

| Contaminant | RME Conc. mg/L | Mol. Wt. g/mol | Henry's Constant atm-m3/mol | Kl cm/h | Kg cm/h | Overall Trans. Coeff. KL cm/h | Temp-adj. Trans. Coeff. KaL cm/h | Conc. leaving H2O Cwd mg/l | VOC Gener. Rate S mg/m3-min | Air Conc. at Shower End mg/m3 | Avg. Air Conc. In Shower mg/m3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Benzene | 1.00E-03 | 7.81E+01 | 5.50E-03 | 2E+01 | 1440.2 | 1.44E+01 | 1.92E+01 | 4.73E-04 | 3.26E-03 | 3.55E-02 | 1.83E-02 |
| cis-1,2-Dichloroethene | 1.30E-02 | 9.70E+01 | 4.08E-03 | 1E+01 | 1292.3 | 1.27E+01 | 1.70E+01 | 5.62E-03 | 3.88E-02 | 4.22E-01 | 2.18E-01 |
| Tetrachloroethene | 5.80E-02 | 1.66E+02 | 1.80E-02 | 1E+01 | 988.5 | 1.02E+01 | 1.36E+01 | 2.12E-02 | 1.46E-01 | 1.59E+00 | 8.20E-01 |
| Trichloroethene | 2.50E-02 | 1.31E+02 | 2.00E-02 | 1E+01 | 1110.3 | 1.14E+01 | 1.53E+01 | 9.99E-03 | 6.89E-02 | 7.50E-01 | 3.87E-01 |
| Vinyl Chloride | 5.00E-03 | 6.25E+01 | 1.20E+00 | 2E+01 | 1610.0 | 1.68E+01 | 2.25E+01 | 2.64E-03 | 1.82E-02 | 1.98E-01 | 1.02E-01 |

Table C14
Adult worker showering inhalation.
Bell Landfill Site
Towanda, Pennsylvania

| | | |
|---|---|---|
| Inhalation rate | m3/min | 0.0138889 |
| Exposure frequency | d/y | 250 |
| Exposure duration | y | 25 |
| Body weight | kg | 70 |
| Averaging time carc. | d | 25550 |
| Averaging time ncarc. | d | 9125 |
| Shower duration | min/d | 12 |

| Contaminant | RME Conc. mg/m3 | Lifetime Average Daily Dose mg/kg/d | Chronic Daily Dose mg/kg/d | Lifetime Cancer Risk | Systemic Hazard Quotient |
|---|---|---|---|---|---|
| Benzene | 1.83E−02 | 1.07E−05 | 2.99E−05 | 3E−07 | 0.2 |
| cis−1,2−Dichloroethene | 2.18E−01 | 1.27E−04 | 3.55E−04 | −− | −− |
| Tetrachloroethene | 8.20E−01 | 4.77E−04 | 1.34E−03 | 1E−06 | −− |
| Trichloroethene | 3.87E−01 | 2.26E−04 | 6.32E−04 | 1E−06 | −− |
| Vinyl Chloride | 1.02E−01 | 5.95E−05 | 1.67E−04 | 2E−05 | −− |
| | Total Route−Specific Risk | | | 2E−05 | 0.2 |

**Table C15**
**Ingestion Exposure Doses and Risks for Child Resident Exposed to Surface Water**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | RME (mg/L) | CR (L/hr) | ET (hr/d) | EF (d/yr) | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFo [(mg/kg/day)−1] | RfDo (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Manganese | 0.796 | 0.05 | 2 | 104 | 6 | 15 | 2190 | 1.5E−03 | 1.3E−04 | NA | 5E−03 | NA | 0.3 |

RME Reasonable Max Exp
CR Contact Rate
ET Exposure Time
EF Exposure Frequency
ED Exposure Duration
BW Body Weight
AT Averaging Time
ADD Average Daily Dose
LADD Lifetime Average Daily Dose
CSFo Cancer Slope Factor (oral)
RfDo Reference Dose (oral)
HQ Hazard Quotient
HI Hazard Index
ND Not Detected
NA Not Applicable

| Total Route−Specific Risk | Cancer | HI |
|---|---|---|
| | NA | 0.3 |

**Table C16**
**Dermal Exposure Doses and Risks for Child Resident Exposed to Surface Water**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | RME (mg/L) | SA (cm2) | PC (1) (cm/hr) | ET (hr/d) | EF (d/yr) | ED (yrs) | CF (L/cm3) | BW (kg) | AT (days) | ADD (mg/kg/day) | LADD (mg/kg/day) | CSFd [(mg/kg/day) - 1] | RfDd (mg/kg/day) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Manganese | 0.796 | 1860 | 1.6E-04 | 2 | 104 | 6 | 0.001 | 15 | 2190 | 9.0E-06 | 7.7E-07 | NA | 1E-03 | NA | 0.01 |

RME Reasonable Max Exposure
SA Skin Surface Area
PC Dermal Permeability Constant
ET Exposure Time
EF Exposure Frequency
ED Exposure Duration

CF Volumetric Conversion Factor
BW Body Weight
AT Averaging Time
ADD Average Daily Dose
LADD Lifetime Average Daily Dose
CSFd Cancer Slope Factor (dermal)

RfDd Reference Dose (dermal)
HQ Hazard Quotient
HI Hazard Index
ND Not Detected
NA Not Applicable

Total Route-Specific Risk

| Cancer | HI |
|---|---|
| NA | 0.01 |

Note: (1) Permeability Constant for water used as conservative estimate for inorganics

**Table C17**
**Ingestion Exposure Doses and Risks for Child Resident Exposed to Sediment**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant of Concern | RME (mg/kg) | IR (mg/d) | CF (kg/mg) | FI | EF (d/yr) | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/d) | LADD (mg/kg/d) | CSFo [(mg/kg/d)]−1 | RfDo (mg/kg/d) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Manganese | 3620 | 100 | 1E−06 | 1 | 104 | 6 | 15 | 2190 | 6.9E−03 | 5.9E−04 | NA | 1.4E−01 | NA | 0.05 |

RME Reasonable Max Exp
IR Ingestion Rate
CF Conversion Factor
FI Fraction Ingested
EF Exposure Frequency
ED Exposure Duration
BW Body Weight
AT Averaging Time
ADD Average Daily Dose
LADD Lifetime Average Daily Dose
CSFo Cancer Slope Factor (oral)
RfDo Reference Dose (oral)
HQ Hazard Quotient
HI Hazard Index
NA Not Applicable

| Total Route−Specific Risk | Cancer | HI |
|---|---|---|
| | NA | 0.05 |

**Table C18**
**Dermal Exposure Doses and Risks for Child Resident Exposed to Sediment**
**Bell Landfill Site**
**Towanda, Pennsylvania**

| Contaminant Of Concern | RME (mg/kg) | CF (kg/mg) | SA (cm2) | AF (mg/cm2) | ABS | EF (d/yr) | ED (yrs) | BW (kg) | AT (days) | ADD (mg/kg/d) | LADD (mg/kg/d) | CSFd [(mg/kg/d)]−1 | RfDd (mg/kg/d) | Cancer Risk | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Manganese | 3620 | 1E−06 | 1860 | 1 | 0.001 | 104 | 6 | 15 | 2190 | 1.3E−04 | 1.1E−05 | NA | 3.0E−02 | NA | 0.004 |

RME Reasonable Max Exp
CF Conversion Factor
SA Surface Area
AF Adherence Factor
ABS Dermal Absorption Factor
EF Exposure Frequency
ED Exposure Duration
BW Body Weight
AT Averaging Time
ADD Average Daily Dose
LADD Lifetime Average Daily Dose
CSFd Cancer Slope Factor (dermal)
RfDd Reference Dose (dermal)
HQ Hazard Quotient
HI Hazard Index
NA Not Applicable

Total Route−Specific Risk NA 0.004

# Appendix D

## Uptake/Biokinetic Model Results

ABSORPTION METHODOLOGY: Non-Linear Active-Passive

AIR CONCENTRATION: 0.200 ug Pb/m3 DEFAULT
Indoor AIR Pb Conc: 30.0 percent of outdoor.
Other AIR Parameters:

| Age | Time Outdoors (hr) | Vent. Rate (m3/day) | Lung Abs. (%) |
|---|---|---|---|
| 0-1 | 1.0 | 2.0 | 32.0 |
| 1-2 | 2.0 | 3.0 | 32.0 |
| 2-3 | 3.0 | 5.0 | 32.0 |
| 3-4 | 4.0 | 5.0 | 32.0 |
| 4-5 | 4.0 | 5.0 | 32.0 |
| 5-6 | 4.0 | 7.0 | 32.0 |
| 6-7 | 4.0 | 7.0 | 32.0 |

DIET: DEFAULT

DRINKING WATER Conc: 19.40 ug Pb/L
WATER Consumption: DEFAULT

SOIL & DUST:
Soil: constant conc.
Dust: constant conc.

| Age | Soil (ug Pb/g) | House Dust (ug Pb/g) |
|---|---|---|
| 0-1 | 644.0 | 200.0 |
| 1-2 | 644.0 | 200.0 |
| 2-3 | 644.0 | 200.0 |
| 3-4 | 644.0 | 200.0 |
| 4-5 | 644.0 | 200.0 |
| 5-6 | 644.0 | 200.0 |
| 6-7 | 644.0 | 200.0 |

Additional Dust Sources: None DEFAULT

PAINT Intake: 0.00 ug Pb/day DEFAULT

MATERNAL CONTRIBUTION: Infant Model
Maternal Blood Conc: 7.50 ug Pb/dL

CALCULATED BLOOD Pb and Pb UPTAKES:

| YEAR | Blood Level (ug/dL) | Total Uptake (ug/day) | Soil+Dust Uptake (ug/day) |
|---|---|---|---|
| 0.5-1: | 5.47 | 16.92 | 11.99 |
| 1-2: | 5.66 | 19.87 | 11.99 |
| 2-3: | 5.80 | 20.56 | 11.99 |
| 3-4: | 5.93 | 20.55 | 11.99 |
| 4-5: | 6.16 | 20.64 | 11.99 |

| | | | |
|---|---|---|---|
| 5-6: | 6.22 | 21.18 | 11.99 |
| 6-7: | 6.25 | 21.64 | 11.99 |

| YEAR | Diet Uptake (ug/day) | Water Uptake (ug/day) | Paint Uptake (ug/day) | Air Uptake (ug/day) |
|---|---|---|---|---|
| 0.5-1: | 2.94 | 1.94 | 0.00 | 0.04 |
| 1-2: | 2.96 | 4.85 | 0.00 | 0.07 |
| 2-3: | 3.40 | 5.04 | 0.00 | 0.12 |
| 3-4: | 3.29 | 5.14 | 0.00 | 0.13 |
| 4-5: | 3.18 | 5.33 | 0.00 | 0.13 |
| 5-6: | 3.38 | 5.63 | 0.00 | 0.19 |
| 6-7: | 3.74 | 5.72 | 0.00 | 0.19 |